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Richard Henry Lewis
(1850–1926)

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PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

DAVIDSON COLLEGE, MAY 6 AND 7, 1927

The twenty-sixth annual meeting of the North Carolina Academy of Science was held at Davidson College, Davidson, N. C., May 6 and 7, 1927. The meeting was called to order promptly at 10:30 a.m. by the president. The reading of papers was begun and continued until 12:45 p.m., when the following committees were appointed:

Nominating—H. B. Arbuckle, A. S. Wheeler, J. P. Givler.

Resolutions—Collier Cobb, J. O. Halverson, Miss Mary F. Seymour.

Auditing—R. W. Leiby, C. F. Korstian, J. B. Derieux.

The Academy adjourned for luncheon.

The reading of papers was begun again at 3:00 p.m., and continued until 5:45 p.m. when the Academy went into business session.

The minutes of the previous meeting were approved as published in the *Journal of the Elisha Mitchell Scientific Society*.

Reports were called for from the following committees:

The High School Prize Committee, consisting of Collier Cobb, chairman, Z. P. Metcalf, and R. E. Coker, reported that Miss Hilda Cook of the Sunderland High School, Concord, N. C., had won the Academy of Science High School Prize for the year 1927. The title of Miss Cook's essay was "My Life History as an Oak Tree." The prize selected by the committee was a loving cup, and H. B. Arbuckle was appointed to

deliver the prize to Miss Cook at the commencement of the Sunderland school.

The Committee on High School Science made a verbal report which was adopted and the committee continued. This committee consists of Bert Cunningham, chairman; R. N. Wilson, secretary; B. W. Wells, C. M. Heck, J. Henry Highsmith and J. N. Couch (H. R. Totten acted for J. N. Couch during the past year).

The Legislative Committee made a verbal report. The committee was thanked by the Academy and continued. This committee consists of Z. P. Metcalf, chairman; Bert Cunningham, Raymond Binford, and H. R. Totten.

The Executive Committee reported as follows:

"The Executive Committee met at Davidson College, May 5, 1927, and again on May 6, 1927, with the following members present: Bert Cunningham, F. E. Rice, H. B. Arbuckle, J. W. Nowell and H. R. Totten.

This Committee makes the following recommendations to the Academy:

(1) That all bills presented in the Treasurer's report be authorized and paid and that the report be printed when audited.

(2) That the Academy pay to the *Journal of the Elisha Mitchell Scientific Society* $200 per year, rather than $175, as at present.

(3) That the Academy send a representative to the high school commencement of the Sunderland School, Concord, N. C., to deliver the Science Essay Prize to the winner; and that the Secretary be authorized to select the Academy representative and to pay from the Academy funds the expenses of this representative.

(4) That the Treasurer pay to the Registration Committee the expenses incurred for the badges for this meeting.

(5) That the Academy send greetings to the Kentucky Academy and to the Virginia Academy, both now in session.

(6) That the Academy accept the invitation from the University of North Carolina to hold the twenty-seventh annual meeting at Chapel Hill."

The recommendations were adopted.

The Committee reported the following elected to membership:

Miss Mabel A. Barkley, Teacher in the Hugh Morrison High School, Raleigh, N. C.

Norman B. Buffaloe, Graduate Assistant in Botany, Duke University.

George Lunsford Carrington, M. D., Durham, N. C.
John Lawrence Cummings, Dept. Chemistry, State College.
Bruce Willis Griffith, Teacher of Science in the Cleveland High School, Cleveland, N. C.
Mrs. Jane Colson Glenn, Prof. of Chemistry, Flora MacDonald College.
J. D. Hardy, Prof. of Biology, High Point College.
Edward Vernon Kyser, Assoc. Prof. of Pharmacy, University of North Carolina.
Frederick J. Holl, Assistant in Zoology, Duke University.
Scott Cary Lyon, Prof. of Biology, Davidson College.
Ella M. Martin, Prof. of Biology, Greensboro College.
Arthur Sperry Pearse, Graduate Prof. of Zoology, Duke University.
Clarence Albert Ruggles, Instructor in Elec. Engineering, Duke University.
Dean Rumbold, Grad. Assist. in Zoology, Duke University.
G. Archie Russell, Chief of Research, Vick Chemical Company, Greensboro, N. C.
Miss Olive Scarratt, Teacher in the Piedmont Junior High School, Charlotte, N. C.
R. M. Warren, Teacher of Chemistry in the Winston-Salem High School, Winston-Salem, N. C.
Samuel Nathaniel Wrenn, Senior in Duke University.
Miss Mabel Louise Bacon, Prof. of Psychology in Peace Institute, Raleigh, N. C.
Charles Nelson Ott, Prof. of Chemistry in Guilford College.
Ona Ruth Whitley, Teacher of Science in the Chapel Hill High School, Chapel Hill, N. C.
J. R. Abernethy, Instructor in Mathematics, University of North Carolina.
W. T. Alexander, Assist. in Botany, University of North Carolina.
A. B. Couch, Assist. in Botany, University of North Carolina.
W. C. Hammond, Senior in the Dept. of Chemistry, University of North Carolina.
Harvey A. Ljung, Senior in the Dept. of Chemistry, University of North Carolina.
Thurman M. Mayfield, New Bern, N. C.
Archie D. Shaftesbury, Dept. of Biology, N. C. C. W., Greensboro, N. C.
W. N. Mebane, Assist. Prof. of Mathematics, Davidson College.
James Reid, Student in Biology, Davidson College.
F. G. Hall, Assist. Prof. of Zoology, Duke University.
Walter J. Seeley, Assist. Prof. of Elec. Engineering, Duke University.
Henry Keppele Miller, Jr., Assist. Prof. of Chemistry, Duke University.
C. R. Hursh, Appalachian Forestry Experiment Station, Asheville, N. C.
P. M. Ginnings, Prof. of Chemistry and Physics, Greensboro College.
Mrs. W. F. Robinson, Prof. of Mathematics, Mars Hill College, Mars Hill, N. C.
M. C. Yoder, Prof. of Biology, Lenoir-Rhyne College, Hickory, N. C.
W. O. Puckett, Assist. in Biology, Davidson College.
G. D. Collins, Assist. Prof. of Physics, Duke University.

Reinstated to membership:
H. P. Barrett, M. D., 211 Vail Street, Charlotte, N. C.
C. W. Styles, M. D., Hygienic Laboratory, Washington, D. C.
S. B. Smithey, Supt. of the Cherokee Indian Normal School, Pembroke, N. C.

The report of the Executive Committee was adopted.

The Auditing Committee made the following report:

"We, your auditing Committee, beg to submit that we have examined the financial accounts of the past Secretary-Treasurer Bert Cunningham covering the period from April 28, 1926, to October 8, 1926, and found them correct.

"We have also examined the accounts of the present Secretary-Treasurer H. R. Totten covering the period from October 8, 1926, to May 4, 1927, and found them correct.

"In both accounts the book balances as shown by bank statements in both the checking and savings accounts agree with their financial statements. The Committee desires to commend the accounting methods of past Secretary-Treasurer Bert Cunningham and present Secretary-Treasurer H. R. Totten."

The report was accepted and the Treasurer instructed to print the financial statement.

The Resolutions Committee reported as follows:

"Resolved that the North Carolina Academy of Science express its its hearty thanks to Davidson College for its generous hospitality; and especially to the following: Messrs. H. B. Arbuckle, W. L. Porter, J. M. Appleby, S. C. Lyon, and O. J. Thies, Jr., chairmen of committees; to Mr. Ernest Milton of the Davidson Press Bureau of Publicity, to the Beavers Club, to the Quadranglers Club, to the Y. M. C. A., and to all who have opened their homes to the members of the Academy.

"We wish also to commend Miss Nell Battle Lewis for the excellent service rendered the cause of education, investigation and freedom of teaching, during the session of the North Carolina General Assembly."

"The Academy mourns the loss by death of one of its most distinguished members, Dr. Richard Henry Lewis (1850–1926), for many years secretary of the State Board of Health, member of the committee that met in Raleigh on March 21, 1902, and organized the North Carolina Academy of Science. His unbiased wisdom, clarity of vision, and gentle and persuasive methods, made his whole life, with its many and varied activities, a source of great good to his state, unsurpassed in his generation.

"While we deeply mourn his passing from among us, we feel that the impetus that many good works derived from his inception and activities will go on forever."

Bert Cunningham, the Academy's representative to the American Association Council gave a verbal report of the Council's activities. His report was accepted.

The Treasurer's report was called for and presented as follows:

Financial Statement

Receipts of Former Treasurer after last audit		Expenditures of Former Treasurer after last audit	
Balance on hand, April 28, 1926	$545.77	Postage	$3.00
Dues collected		Stenographer	6.00
April 28—June 5	92.00	Balance on Sec.-Treas. Com. and expenses	18.10
June 5—Aug. 1	2.00		$27.10
Interest on savings account to Oct. 8	7.26	To balance	621.93
Allotment from A. A. A. S.	2.00		$649.03
	$649.03		

Receipts of Present Treasurer		Expenditures of Present Treasurer	
Received from former treasurer	$621.93	Stationery and postage	$46.35
Dues		Printing, mimeo., multi. and addressograph	63.13
1925-26	6.00	Journ. E. M. Sci. Soc	175.00
1926-27	212.00	Sec.-Treas. Com.	27.40
Initiations	58.00	Dues refund to Sec	2.00
Chemists programs	5.00	Expenses of Sec	9.98
Allotments from A. A. A. S.	44.50		$323.86
Interest on Savings account	6.80	To balance	630.37
	$954.23		$954.23

Comparison

	1925-26	1926-27
Savings Account	362.96	441.02
Checking Account	182.81	189.35
	545.77	630.37
To balance	84.60	
	630.37	

The above report was made as of May 4, 1927.

Submitted by

H. R. Totten, *Secretary-Treasurer.*

Audited by

R. W. Leiby, C. F. Korstian, J. B. Derieux.

The Treasurer's report was accepted.

The Nominating Committee made the following nominations:

President—J. M. Bell, University of North Carolina.

Vice-President—W. L. Porter, Davidson College.

Secretary-Treasurer—H. R. Totten, University of North Carolina.

Member of the Executive Committee for three years—A. H. Patterson, University of North Carolina.

Representative to the American Association Council for two years—Bert Cunningham, Duke University.

These were elected by acclamation.

Upon the call for further business, H. B. Arbuckle moved that the constitution of the Academy be amended, in agreement with the recommendation submitted to the Academy at its last annual meeting, so as to provide for the election of the Secretary-Treasurer for a period of three years.

The constitution was so amended by a more than two-thirds vote of those present.

A. S. Wheeler presented a resolution that at the next annual meeting the Academy further amend its constitution so as to provide for the election of the Secretary-Treasurer for a period of six years.

The business meeting of the Academy was then adjourned, and the Academy next met for supper at the hotel as guests of Davidson College.

The Academy reconvened at 8:00 p.m. with Vice-President Rice presiding. President Martin welcomed the Academy to Davidson College. Vice-President Rice responded for the Academy, and then presented President Cunningham who delivered the presidential address on "Contributions of Experimental Embryology to the Study of Germinal Organization." After this address an informal social hour was held at the Quadranglers Clubrooms and at the Y. M. C. A.

The Academy convened in sections Saturday morning with President Cunningham presiding over the non-section group, J. N. Dobbins over the chemists, A. W. Hobbs over the mathematicians, and W. M. Nielson over the physicists.

The following group officers were elected for the year 1927–28:

Chemistry, P. M. Ginnings of Greensboro College, chairman; L. B. Rhodes of the State Dept. of Agriculture, secretary; A. S. Wheeler of the University of North Carolina, councillor. Mathematics, W. W. Rankin of Duke University, chairman; W. W. Elliott of Duke University, secretary. Physics, J. M. Douglas of Davidson College, chairman; C. C. Hatley of Duke University, secretary.

In the non-section group, in addition to the reading and discussion of papers, Poche's propositions on nomenclature were taken up and this section, containing among others the biologists of the Academy, voted to support the Americans objections to Poche's propositions.

The following papers were presented. Those marked with an * appear in full in this issue; those marked x are abstracted in this issue; for those unmarked no abstracts were received; those marked † were presented by title only.

**A Study of Certain North Carolina Waste Materials.* E. E. RANDOLPH, State.

A Sooty Mold of the Peach (Lantern). G. W. FANT, State.

**Insulation for Refrigeration.* W. C. HAMMOND AND F. C. VILBRANDT, University.

Sweet Potato Storage Rots and the Possibility of Controlling Them Economically with Non-Poisonous Chemicals (Lantern). R. F. POOLE, State.

**Some Dangers in Specialization.* GEORGE W. LAY.

x*Studies in the Plant Ecology of the Mount Mitchell Area* (Lantern). JOHN H. DAVIS, JR., Davidson.

x*Evaporated Milk, its Chemistry and Uses.* F. E. RICE, State.

x*The Story of Light in the Nutrition of Animals* (Lantern). J. O. HALVERSON, State Dept. of Agr.

**Cave Fauna with Especial Reference to Ecological Factors.* J. D. IVES, CARSON AND NEWMAN.

†*The Problem of Human Motivation.* J. F. DASHIELL, University.

x*The Pyrophyllite Deposits of Moore County, North Carolina.* JASPER L. STUCKEY, State.

x*North Carolina Pyrophyllite as an Ingredient in Ceramic Bodies.* G. R. SHELTON, State.

x*Our Changing Environment in North Carolina* (Lantern). COLLIER COBB, University.

x*The Migration of Animals from the Ocean to Land and Fresh Water Habitats* (Lantern). A. S. PEARSE, Duke.

†*The Production of Oil of Chenopodium in the United States.* E. V. KYSER, University.

x*A Cercospora Leaf-Spot of Soy Beans* (Lantern). S. G. LEHMAN, Agr. Exp. Sta.

†*Some Observations on Living Sponge Cells in situ and in vitro.* H. V. WILSON, University.

x*The Structure and Development of Flax Fiber* (Lantern). DONALD B. ANDERSON, State.

†*The Structure of Cotton Fiber* (Lantern). DONALD B. ANDERSON, State.

†*The Wintering of the Honeybee in North Carolina.* F. B. MEACHAM, State.

Oenocytes of the Honeybee (Lantern). ARCHIE D. SHAFTESBURY, N. C. C. W.

†*Appalachian Structures of Southeastern West Virginia.* W. F. PROUTY, University.

†*The Chattanooga Age of the Big Stone Gap Shale of Southwestern Virginia.* J. H. SWARTZ, University.

**Collybia dryophila; its Parasitism, Isolation and Culture* (Lantern). R. F. POOLE, State.

x*Cytological Studies of Exoascaceae,—Taphrina Johansonii and Taphrina deformans* (Lantern). ELLA M. MARTIN, Greensboro College.

**Life History of the Plum-Curculio.* C. H. BRANNON, State.

x*A Nematode Parasite Found in Triturus viridescens (Rafinesque).* F. J. HOLL, Duke.

The Morphology of the Intestine of the Cotton Boll Weevil (Lantern). R. W. LEIBY AND J. A. HARRIS, Agr. Exp. Sta.

x*Soils and Civilization.* COLLIER COBB, University.

An Important Group of Fungi Recently Found in the Soil (Lantern). W. C. COKER, University.

[The essential material in this and the following five papers was published in Journ. E. M. Sci. Soc. **42**: 207, 1907, under the title of *Other Water Molds from the Soil.*]

Two New Water Molds from the Soil. W. T. ALEXANDER, University.

A Peculiar New Water Mold from the Soil. H. H. BRAXTON, University.

An Apparent Mutation in a Species of Achlya from the Soil. H. H. BRAXTON, University.

A New Heterothallic Achlya. A. B. COUCH, University.

The Genus Aplanes. VELMA MATTHEWS, University.

**Fertilization and Oogenesis in Achlya colorata.* PAUL M. PATTERSON, University.

†*What is a Species?* J. H. SWARTZ, University.

Recent Observations on Citrous Melanose. FREDERICK A. WOLF, U. S. Dept. of Agr.

x*A Comparison of the Development of Soils from Acid and Basic Crystalline Rocks.* W. B. COBB, State.

Blood Concentration Studies in Marine Fishes (Lantern). F. G. HALL, Duke.

†*On the Relations between Knowledge of and the Ability to do Problems in Physics.* G. HERBERT COLE, Guilford.

Spreading out the Heavens (Lantern). A. H. PATTERSON, University.

The Dissociation of Hydrogen Chloride by Positive Ion Impact. WALTER M. NIELSON, Duke.

x*A New Thermoregulator.* S. C. COLLINS (Introduced by Otto Stuhlman, Jr.), University.

x*A Note Concerning the Thomson Theories as to the Structure of Light.* C. W. EDWARDS, Duke.

x*An Electron Theory of Valence Based on an Extension of the Bohr-Stoner Electron Distribution in Atoms.* OTTO STUHLMAN, JR., University.

x*Correlations and Systems of Conics.* J. W. LASLEY, University.

Double Spiral Motion. A. W. HOBBS, University.

General Proof of the Binomial Theorem by Divided Difference. JOHN R. ABERNETHY, University.

Summability of Infinite Products. G. M. ROBISON, Duke.

The following papers were presented to the North Carolina section of the American Chemical Society:

Report on High School Chemical Essay Contest. L. F. WILLIAMS.

x*The Dietary Factor of Reproduction.* J. O. HALVERSON.

x*Infant Stomachs and Colloid Chemistry.* F. E. RICE.

The Nitration of 2-amino-p-cymene. A. S. WHEELER AND F. P. BROOKS.

The Bromination of 4-m-Xylidine. A. S. WHEELER AND O. B. HAGER, JR.

1-Phenylcarbamyl-3, 5-dimethylpyrazol. A. S. WHEELER.
Progress Charts in Elementary Chemistry. P. M. GINNINGS.
x*Asphaltogenic Bodies in American Oils.* L. A. BASS AND F. C. VILBRANDT.
x*Reclamation of Crank Case Oils.* A. R. GREEN AND F. C. VILBRANDT.
**Studies in Chemical Industries of North Carolina III.* F. C. VILBRANDT.
Preparation of Fluorine. JOHANNES S. BUCK.
Estimation of Nickel in Steel. C. L. M. THOMAS.
**A Zinc Spot in Marsh's Test for Arsenic.* H. B. ARBUCKLE AND O. J. THEIS, JR.
The Thermocouple as a Precision Thermometer. PAUL GROSS AND HENRY K. MILLER.
Electrometric Estimation of Copper. J. T. DOBBINS AND J. B. BULLITT, JR.
Reduction of Nitra Compounds by Titanium Chloride. J. T. DOBBINS AND H. A. LJUNG.

The following abstracts have been received:

Studies in the Plant Ecology of the Mount Mitchell Area. JOHN H. DAVIS.

A discussion was given of the ecological groupings, associations, societies, etc., most characteristic of the region around Asheville and Mount Mitchell, the floristic composition, dominant species, physiognomy, etc. The main part was a discussion of some of the environmental factors and more particularly the results of certain studies in evaporation that have been made. With the use of the Livingston porous cup atmometer a rather definite correlation between the evaporation rates at different altitudes in similar associations has been found.

The report is a preliminary one, and the work will require two or more summers to complete it.

Evaporated Milk, its Chemistry and Uses. FRANK E. RICE.

North Carolina has one-fortieth of the human population of the United States but only one-seventieth of the cow population. The per capita milk consumption of the whole country is by no means up to the optimum, consequently it is evident that that of our own state should be greatly increased.

The cheapest source of milk food is, in most cities, evaporated milk. A can of this product purchased from the grocer can be used for preparing a quart of milk at a cost of 12⅓ cents. Furthermore, it is readily

available and easily handled. It is digestible and free from disease germs.

In the preparation of evaporated milk the bacteria are destroyed by the application of heat. What is the effect of this heat treatment on the nutritive value of the milk? Calcium, phosphorus and other mineral constituents have been found to be just as high in nutritive value in heated milk as in unheated. The same holds for the protein. The protein of raw cow's milk forms a hard curdy mass in the stomach, a condition which may disturb digestion particularly in the infant. Evaporated milk, under the same conditions, forms small curds; in this respect its behavior is very similar to that of human milk. Vitamins A and B are not injured in the process of sterilizing the milk, but vitamin C is destroyed; however, raw cow's milk has never been considered to be an important carrier of vitamin C. There is no enzyme, antibody or mysterious "living substance" in raw milk of peculiar value to the human race, consequently any destruction of such things as these in the sterilization process would be of no consequence.

In one stage of the process of manufacture of evaporated milk the fluid is put through an homogenizer which breaks up the fat globules, increasing the number several hundred times. This greatly increases the digestibility of the fat.

In the preparation of the lactic acid milks such as *Acidophilus* it is necessary that the growth of foreign bacteria be prevented. Evaporated milk, being germ-free, is convenient and satisfactory as the form of milk in which to grow the lactic-acid bacteria.

Conclusions.—Evaporated milk is a nutritious food which should be made a part of the diet wherever possible. It is particularly suitable for infant feeding, where a digestible and germ-free form of milk is demanded. It is cheap, easily procured and handled, and free from dangerous bacteria.

The Story of Light in the Nutrition of Animals. J. O. HALVERSON.

The subject deals with rickets illustrated by skeletons of several small animals (albino rat) fed peanuts, hominy grits, salts, and distilled water.

The recent work of McCollum and his co-workers definitely showed the factors concerned in the production of rickets. The Edinburgh school of workers held tenaciously to their views that light (sunlight) was a factor in human rickets; that in its incidence and cure, light played an important part. For several years it was difficult to har-

monize these views. It was later found that sun light was effective in curing experimental rickets. Hess and his workers had observed a seasonal incidence of rickets in New York City. They associated this with the milk supply—winter and summer milk, the latter causing cures and referred this to the green grass diet of the cow.

At the Wisconsin Agricultural Experiment Station the effect of sun cured hay and hay cured on dark days, on calcium metabolism was observed. This was later shown to be correlated with the influence of light in the prevention of rickets and culminating in the use of artificial light, especially the use of the Quartz Mercury Vapor Lamp (the ultra violet light) on rations and its ability to cure rickets by changing the ration in some way.

Its practical use in foods was only mentioned.

The Pyrophyllite Deposits of Moore and Chatham Counties, North Carolina. JASPER L. STUCKEY.

Pyrophyllite, the hydrous aluminium silicate, $H_2Al_2Si_4O_{12}$, is well known to teachers of mineralogy; but it is seldom thought of as one of the minerals of commercial importance. This is probably due to its being physically so much like talc and also to the fact that it is commonly sold as talc.

The only commercial deposits of this mineral known in the United States are found in Moore and Chatham Counties, North Carolina. Mining operations have been carried on near Glendon and Hemp in Moore County and the known deposits contain large reserves of high grade pyrophyllite which can be easily mined.

The mineral bodies lie along the eastern edge of the "Carolina Slate Belt." The rocks of the area consist of volcanic flows, tuffs and breccias with some beds of true shale all of which have been metamorphosed into "slate." The flows, tuffs and breccias are chiefly rhyolitic in composition. Small amounts of andesitic material are occasionally found. The pyrophyllite bodies are oval or lenticular in shape and lie along a narrow zone aligned with the strike of the formations. They vary in width from 200 to 500 feet and in length from 500 to 2000 feet. The pyrophyllite is in every case associated with acid tuff or breccia. The chief minerals in the deposits in the order of their importance are pyrophyllite, quartz, chloritoid, sericite, pyrite, chlorite and iron oxides. The pyrophyllite bodies have been formed by metasomatic replacement of acid volcanic rocks under conditions of intermediate temperatures and pressure.

North Carolina Pyrophyllite as an Ingredient in Ceramic Bodies. G. R. SHELTON.

The physical and chemical properties of pyrophyllite are such that it presents a number of possibilities as a constituent of ceramic bodies.

Preliminary tests on a white earthenware body, made by combining pyrophyllite with domestic clays, feldspar and quartz, indicate that ware can be successfully made by the processes of casting, jiggering and pressing. When the test pieces were fired to cone 6 (1270°C.) the color was slightly off, a faint gray tint being developed. Further tests will be necessary to determine the source of this tint. Good results were obtained in glazing the biscuited body with a raw lead glaze maturing at cone 1 (1150°C.).

The investigation is being continued to determine the possible uses of pyrophyllite as a body ingredient for making such ware as wall tile, floor tile, refractory porcelains and sanitary ware.

Our Changing Environment in North Carolina. COLLIER COBB.

While weather records in North Carolina, taken at Chapel Hill since 1820, and at a number of other stations for little less time, show little if any change in our climate, old maps dating back to the middle of the Seventeenth Century show a *Deserta Arenosa* in our sandhills region, and local tradition in our piedmont tells of prairie lands there for fully a century later, over which buffalo then wandered. Our mountains show the narrow ridge lines characteristic of mature mountain erosion in a region without forests such as we see in the mountains of deforested northeastern China.

In proof of the former treeless condition of the piedmont the oldest inhabitants in my youth pointed out that there were no trees on the generally level uplands more than a hundred years old, and that all the older trees were found on the banks of streams; also that the tall pines of the sandhills were not older than this when their general destruction began about 1890.

A marked change in the forest cover of North Carolina has taken place even within my memory, which extends over a period of sixty years. The sandbanks that fringe our coast were forest-covered for two or three years after the civil war, until "live-okers" from New England sought there ship timbers and tall masts for the revival of ship building. The neglected cotton lands of our lower coastal-plain soon grew up in tall pines, which have been cut out in the last few years, chiefly by the Roper Lumber Company. If we will assist nature in a few cases and leave her

alone in some others our State will again have the finest body of forest land in our country.

The most important change in our environment, to which so much of our advancement is due, is the improved means of communication and transportation—before which the peculiarities of low-landers, up-country people, and mountaineers are disappearing. To be considered in this connection is the remarkable development of our hydro-electric power that is revolutionizing our manufacturing methods; and the time is not far distant when the coal will be burned at the mine and the power sent by wire to the place where it may be utilized. The transportation of coal adds too greatly to its cost and is a great hindrance to railway traffic in general.

The Migration of Animals from the Ocean to Land and Freshwater Habitats. A. S. PEARSE.

Various lines of evidence indicate that animals originated in the ocean and have since Cambrian times gradually invaded land and freshwater habitats. In going into freshwater, adjustments in the blood and body fluids have been necessary. In the invasion of the land, adaptations to prevent loss of water from the body and drying out of respiratory membranes have developed. The routes followed by animals in passing from the ocean appear to have been as follows:—(1) Burrowing animals in the ocean bottom moved into the bottoms of freshwater streams and swamps or into the soil. (2) Some animals went through the intertidal zone directly to the land. (3) Other animals became adjusted to marshes and swamps; in some cases later to land. (4) There was a movement of animals from the ocean into rivers; and later to land in a few instances. (5) The dilution of portions of the ocean by heavy rains, or by enclosure within land basins and the taking in of freshwater apparently led some animals to live in freshwater. When animals have through succeeding generations forsaken the ocean and taken up life in freshwater or land habitats they have apparently done so on account of:—(1) the lure of oxygen in the atmosphere, (2) greater security, (3) temporary or permanent lack of water in available habitats, (4) food, or (5) more favorable conditions for reproduction.

A Cercospora Disease of Soy Bean. S. G. LEHMAN.

This disease was first found in North Carolina in late September, 1925, but previously had been described from Manchuria in 1918. It is now known to be well distributed over Eastern North Carolina and

is also present in several other southern states. Lesions have been observed only on leaves. They appear as light brown or tan colored areas bordered by a narrow band of dark brown tissue.

The disease is caused by a hyphomycete, *Cercospora diazu* Miura, which fruits on both surfaces of the lesions, can be isolated easily, and grows readily in culture. The disease occurs most abundantly on such favorite varieties as Laredo, Biloxi, and O-too-tan. Our most widely grown variety, Mammoth Yellow, shows moderate resistance to the disease. Diseased spots are sometimes present in such abundance as to give a yellow aspect to an infested field. It is probably seed borne, and very likely came to America on seed imported from the Orient.

The Structure and Development of Flax Fiber. D. B. ANDERSON.

A paper presenting the results of a microchemical study of the flax fiber during its development. The fiber is shown to be formed by the periodic addition of lamellae of pure cellulose. This deposition of definite layers of cellulose begins at the lower end of the fiber cell while the upper end is still elongating. The lamellae are not cemented to each other and may be separated from one another in mature fibers by proper treatment. Each lamella is shown to be formed of long spirally wound crystals of cellulose. The direction of the spirals is reversed in different lamellae. This may be the result of isomeric celluloses. This spiral structure of the flax fiber is not peculiar to that kind of a cell alone but is probably related to the nature of cellulose itself.

The Structure of Cotton Fiber. D. B. ANDERSON.

Cotton fiber is composed of a number of layers of pure cellulose. These layers may be separated from each other by proper treatment. Each layer is composed of spirally wound fibrils. The fibrils are doubly refractive and hence are crystalline. Cotton fiber in spite of its different origin shows fundamentally the same type of structure as do the bast fibers.

Cytological Studies of the Exoascaceae. Taphrina Johansonii and *Taphrina deformans.* ELLA MAY MARTIN.

A cytological study has been made of different species of *Taphrina* with the purpose of determining the number of nuclei in the cells, the origin and development of the ascus, and the formation of ascospore nuclei and ascospores. It is found that *Taphrina Johansonii* which infects the fruits of the trembling aspen and *Taphrina deformans* which

produces peach leaf curl follow very closely the life history of a typical *Taphrina* as described previously for *Taphrina coryli*.[1]

Vegetative cells of *Taphrina Johansonii* and *Taphrina deformans* form long dichotomously branching filaments which distribute the fungi between the cells of the hosts. The vegetative cells are binucleate, and from them are produced ascogenous cells which are binucleate. There is therefore no necessity for the theory of pairing of ascogenous cells to account for the presence of the two nuclei in these cells. One nuclear fusion takes place, and that is in the ascogenous cells. This fusion represents the remains of a sexual process in these species of *Taphrina*, and it is followed by the growth of the ascus directly from the ascogenous cell. The first division of the fusion nucleus in the ascus is a heterotypic division as indicated by the occurrence of synapsis, a contraction phase, and thickened chromosomes. Centrosomes and astral rays are persistent structures, except in connection with the resting nucleus. The nucleole may also remain for some time after a spindle is formed. Eight nuclei are formed in the ascus for the eight primary ascospores. Astral rays apparently have nothing to do with the delimitation of the spores. Instead, vacuolar membranes appear to delimit spores.

The eight primary ascospores, by a process similar to budding, form many secondary spores either in the ascus, on agar or on the surface of the host. These secondary spores or conidia are also uninucleate but they germinate to produce vegetative hyphae which later become binucleate. Within the host, vegetative cells are always binucleate. Although these species of *Taphrina*, have been grown on various kinds of agar for more than three years, no conjugation of conidia as described by Miss Wieben (1927) has been found. Since no conjugation of the conidia is apparent on agar or on the surface of the respective hosts, there must be some other means by which vegetative cells become binucleate. From these preparations, it is probably through nuclear division that the binucleate condition arises in the vegetative cells.

A Trematode Parasite of Triturus viridescens (Rafinesque). FRED J. HOLL.

While studying the parasites of the salamander, *Triturus viridescens* (Rafinesque), I have found an intestinal fluke which is apparently in a new genus of the family Plagiorchiidae. I have examined *Triturus*

[1] Martin, E. M. Cytological studies of *Taphrina coryli* Nishida. Trans Wisconsin Acad. Sci. **21**: 345–356. 1924.

collected from an artificial lake near Durham, N. C., and one at Lakeview, N. C. These lakes are within eighty miles of each other and the one at Durham is about 25 years of age while the one at Lakeview is about 10 years. At Durham I found sixty-two per cent of the salamanders parasitized while only twenty-two per cent at Lakeview. Fifty-two per cent at Durham had intestinal flukes and thirty-nine per cent had the apparently new species. There were no intestinal flukes found at Lakeview. At I Durham thirty-one per cent had bladder flukes while only nineteen per cent at Lakeview. In the collecting at Lakeview no snails were found, which may account for the absence of intestinal flukes.

Soils and Civilization. COLLIER COBB.

The paper was based on field studies of grain-producing soils extending entirely around the earth in the cooler regions and also just north of the tropics, the type-civilizations studied being that of rice in Malaya, of wheat in Mesopotamia, and of maize in the Maya region. The soils in these three regions consist largely of rock material, whether of desert origin or due to glacial action, in which there is at the time an interaction between these inorganic materials and the organisms present in the soil. The grain-producing value of such soils in comparison with the older, deeper soils may be seen by comparing the glaciated soils of northern Illinois and a narrow strip in northern Missouri with the less productive, though far deeper, soils south of the glaciated district. This is but a report of progress in studies begun in the eighties. These studies will be carried forward in the field in Canada during the coming summer.

A Comparison of the Development of Soils from Acid and Basic Crystalline Rocks. WM. BATTLE COBB.

In studying the chemical changes which take place during the weathering of rocks into soils it has generally been customary to consider paired analyses, i.e. the composition of the fresh rock and of one weathered product only. The present paper considers various stages of weathering as represented by soils of different degree of development. Another departure from the usual method is that gains are considered as well as losses. The data collected show that no constituent of the rock remains constant as development proceeds. It has usually been assumed that Al_2O_3, Fe_2O_3 or SiO_2 has remained constant. It is found that there is one actual increase in the amount of Al_2O_3 in sub-

soils and in the weathered rock beneath the subsoils of all except the younger soils. There is an initial loss of Fe_2O_3 in younger soils followed by gains in the older subsoils and older weathered rock. In the rocks and soils studied there is always a loss of silica in every stage of weathering. All of the surface soils show a loss of each of the mineral constituents.

In the acid rock series there is a steady decline in potash content, the older soils having the smaller amount while in the basic rock series there is a large initial loss followed by a small but steady increase as development proceeds. There is a steady decline of soda in both cases. Lime and magnesia decrease steadily in the basic series while there is some indication of a tendency for their early loss to be followed by slight gains in the acid rock series.

In the early stages of weathering the loss of constituents from the acid rock is much less than that from the basic rock, but the older soils from basic rocks show less total loss than the older soils from acid rocks. However, the gains in the older soils from acid rocks are greater than in those from basic rocks. These gains are principally in Fe_2O_3 and Al_2O_3.

A New Thermoregulator. S. C. COLLINS. (Introduced by O. Stuhlman, Jr., University of North Carolina.)

The thermoregulator described is operated directly by a 110-volt alternating current without the use of dry cells or sensitive relay. The heating effect is produced by passing the electric current through the water bath itself, the water being made conducting by addition of salt. The sensitive member depends for its motion upon the differential expansion of air and the saturated vapor of ether or other liquid. The heating current is applied continuously and is adjusted by an automatic rheostat to a value that will just compensate for heat losses. The variation in temperature under average operating conditions can be expected not to exceed 0.02°C.

A Note Concerning the Thomson Theories as to the Structure of Light. C. W. EDWARDS.

The beginner in physical science is prone to take physical theories too seriously. One frequently confuses theory with fact. Even the so called exact results of mathematical physics must be taken with a grain of salt until they are checked up by thorough experimentation. The ease with which the seasoned physicist sets up a theory, quite ob-

viously far from consistent with itself, uses it for his immediate purposes and then knocks it down again is disconcerting to the novice. It is by some such process that the great advances in physical science have been made. In no branch of science has a greater variety of theories been advanced than in the study of light and of the considerable number of recent speculations, those of Sir J. J. Thomson probably illustrate most strikingly the process in question. Thomson's theories as set forth in Recent Researches (1892), the Silliman lectures, Yale University, on Electricity and Matter (1914), and the Fison Memorial lectures (1925) were compared in illustration of the process.

An Electron Theory of Valence Based on an Extension of the Bohr-Stoner Electron Distribution in Atoms. OTTO STUHLMAN, JR.

Stoner's modification of the Bohr electron distribution in atoms is extended and coordinated with the ionization and critical potential data available for the first long period in the Periodic Table. This leads to an electron distribution after the Argon (18) closed atom kernel, of the following energy levels:

	A	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Z.....	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
3_{22}				1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4
3_{33}								1	2	3	4	5	6	6	6	6	6	6	6
4_{11}		1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4_{21}														1	2	2	2	2	2
4_{22}																1	2	3	4

It can be shown that the valence of anions are attributable to the (non-polar) action of the completed doublet levels and that the cation valences are due to the action of the external levels acting in conjunction with the incompleted, paired levels.

Correlations and Systems of Conics. J. W. LASLEY.

In the theory of planar collineations the characteristic equation may be reduced from determinant form to polynomial form by means of principal minors of various orders in the determinant. The theory of planar correlations leads to a characteristic equation so different in its determinant form from that of the collineations as to make unavailable the method employed there. In this paper a reduction is made by

means of the similarity between the determinant here involved and that in the theory of two conics, some theory of quadratic forms, and the sum of the product of the elements of a determinant and the corresponding elements in its adjoint.

A Dietary Factor in Reproduction. J. O. HALVERSON.

The recent work of Evans and Associates of the University of California, on the study of reproduction in the white rat, was briefly reviewed. They showed that there was another unknown factor present in diets which prevented the resorption of foetuses at 14 to 17 days. These workers first eliminated all the known vitamins and minerals and adequate proteins in diets by controlling them in their studies.

They found this unknown factor present in greatest abundance in an ethereal extract of wheat embryo which when supplied to a pregnant rat receiving a purified ration deficient in this respect, was able to produce and rear her young.

This unknown dietary substance was first called vitamin X but now is known as "vitamin E."

Infant Stomachs and Colloid Chemistry. FRANK E. RICE.

Cheese is manufactured commercially by allowing rennet or pepsin to act on warm milk which has become slightly acid. Cow's milk, taken into the stomach, meets exactly these conditions, and as a result cheese-like masses of casein are produced. Human milk, on the other hand, precipitates in small curds. The principles involved in the precipitation of casein by rennet are as follows: (1) The presence of calcium ion, or the relative proportion of calcium ion to sodium and potassium ion, (2) the relative proportion of albumin to casein in the milk, and (3) the colloidal nature of the casein itself.

Observations which are explained on the basis of these principles are as follows: Milk does not precipitate with rennet or pepsin at all, or at any rate very slowly if there has been added—ammonium oxalate, sodium bicarbonate, sodium citrate, or sodium hydroxide. In these instances the dissociation of calcium ion is forced back, or else soluble calcium is precipitated; or, the preponderance of sodium ion has prevented the adsorption of the calcium ion by the casein particle. Human milk and asses' milk contains a much higher proportion of albumin to casein than does cow's milk; the albumin has a protective action in preventing the agglomeration of the casein particles. The addition of albumin, starch or gelatin to milk hinders the rennet precipitation for the same reason. When milk is exposed to a high temperature the col-

loidal nature of the casein is changed to such an extent that heavy casein curds are not formed under the action of rennet or pepsin.

Some of the methods that have been used for the modification of cow's milk for infant feeding are as follows: the addition of sodium bicarbonate, sodium citrate, starch, gelatin, albumin, and the application of heat. In each case the purpose has been to cause the casein to precipitate out in the form of small flakes instead of heavy curds.

Evaporated milk is especially suitable for the feeding of infants for the reason that the heat which is employed in the sterilization process modifies the colloidal nature of the casein to such an extent that it precipitates with enzymes very much as does human milk.

A study has been made of the milk of different cows for the purpose of finding milks that show precipitation behavior most like human milk.

Asphaltogenic Bodies in American Lubricating Oils. L. A. BASS AND F. C. VILBRANDT.

A study of the various methods suggested for the determination of asphaltogenic bodies, which have been claimed to be responsible for the so-called carbon formation in internal combustion engines was made on several well-known lubricating oils before and after use in automobiles in service. A comparison of the results obtained show that either erstwhile methods of testing, which are of European origin, are inapplicable to our American oils, or, that the latter oils do not contain asphaltogenic bodies in quantities sufficient for detection under the tested conditions, or that asphaltogenic bodies are not responsible for carbon deposition.

Reclamation of Crank-Case Oils. A. R. GREENE AND F. C. VILBRANDT.

A continuation of the studies on used lubricating oils obtained from an engine under controlled conditions was made to ascertain which methods of reclamation and methods of testing oils were applicable to this economic salvage of valuable oils. Thirteen oils were studied under varying running conditions and the used oils subjected to seven different reclamation treatments. Specification methods and some new proposed tests were used for evaluation tests. Chemical, mechanical and combination treatments of reclamation were made in this investigation. The results indicate that viscosity tests alone were the best criteria to detect changes occurring on treatment of oils. None of the reclamation treatments showed complete removal of extraneous materials from the oils, yet the products from some of these treatments were again valuable lubricating oils, while other methods were ineffectual.

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

The Elisha Mitchell Scientific Society, composed of faculty and advanced students from the Scientific Departments of the University, numbered for the year 1926–27, 204 members (65 active and 139 associate). The officers of the Society were: *President*, Collier Cobb; *Vice-President*, W. C. George; *Permanent Secretary*, J. M. Bell; *Recording Secretary*, E. T. Browne; *Editors of the Journal of The Elisha Mitchell Scientific Society*, W. C. Coker, A. S. Wheeler, and W. F. Prouty. Fourteen papers were presented at the eight meetings held during the year. Of these, twelve were presented by members of the faculty of the University, one was presented by an advanced student in Psychology, and one was presented by a Professor of Biology in Duke University.

Programs of the Elisha Mitchell Scientific Society during 1926–27 are as follows:

290TH MEETING, OCTOBER 19, 1926

COLLIER COBB—*Coast Erosion and Shoreline Protection.* (Illustrated). Abstracted in this issue.

291ST MEETING, NOVEMBER 9, 1926

F. P. BROOKS—*New Derivatives from North Carolina Spruce Turpentine.*

A. W. HOBBS—*Note on the Conical Helix.*

292ND MEETING, DECEMBER 14, 1926

G. M. BRAUNE—*Researches on Culvert Pipes.*

E. K. PLYLER—*The Determination of Isotopes by the Lines of Spectra.* Abstracted in this issue.

293RD MEETING, JANUARY 11, 1927

F. K. CAMERON—*An Unusual Case of the Leaching of Copper.*

294TH MEETING, FEBRUARY 8, 1927

A. H. PATTERSON—*A Novel Design for a Gyro-Compass.* Abstracted in this issue.

W. C. GEORGE—*The Histology of the Blood of Some Bermuda Ascidians.* Abstracted in this issue.

295TH MEETING, MARCH 8, 1927

W. C. COKER—*Some Remarkable New Fungi from Chapel Hill Soil.*

J. C. BAGWELL—*Studies of Direction Trends in Maze Learning of White Rats.* Appearing in this issue.

296TH MEETING, APRIL 12, 1927

A. S. PEARSE, Research Professor of Zoology in Duke University. *Life in Nigeria.* (Illustrated).

297TH MEETING, MAY 10, 1927

T. F. HICKERSON—*A New Formula for Column Strength.* Appearing in this issue.

J. H. SWARTZ—*The Correlation and Origin of the Chattanooga Shale of Tennessee and Virginia.*

COLLIER COBB—*A Sperm Whale from the Miocene (?) of Florida.* Abstracted in this issue.

On Coast Erosion and Shoreline Protection. COLLIER COBB.

Studies of the shoreline from New Smyrna, Florida, to Sandy Hook, New York, made from June 1926 to May 1927, show that coast erosion is checked better by the straight groyne or jetty than by the same kind of structure with the off-shore end curved—a type so long in use in Europe and along our own New Jersey shore,—and better by the stone jetty constructed of rip-rap than by the wooden jetty built of timber piles and heavy lumber, and better by a solid jetty than by an open one; that the current next shore in the region is just as likely to run north as south, and that its direction may not be constant throughout the year; and that each limited strip of shoreline presents an individual problem to which general principles do not apply, requiring special investigation to determine the method necessary to employ for its protection.

A Sperm Whale from the Miocene (?) of Florida. COLLIER COBB.

Photographs of two long bones dug up by Mr. S. T. Early, of Asheville, N. C., were submitted for identification. These were taken from

a point among the dunes near the shore between Fort Worth, Florida, and Palm Beach, Florida. The two specimens, one 15 feet and 8 inches in length, and the other 16 feet in length, constituted the lower jawbone of a cachelot or sperm whale, with which were also found ten ivory teeth. Up to this time all that has been found of the sperm whale in fossil form is a single large somewhat mutilated tooth from the Miocene of North Carolina, described by Leidy, in the Proceedings of the Academy of Natural Sciences, Philadelphia, vol. ii, p. 162, 1859. Leidy named the fossil *Onocetus emmonsi;* and in the same paper he described the *Dromatherium sylvestre,* then supposed to be a little pouched marsupial somewhat larger than a rat but now regarded by geolosists as a theromorph reptile. The *Dromatherium* was found in Triassic rocks of the Deep River area, in what was then Chatham County, now Lee.

The photographs of the specimens were sent to me by Mr. D. R. Barbee, Managing Editor of the *Asheville Citizen.*

The Determination of Isotopes by the Lines of Spectra.[1] E. K. PLYLER.

Since Aston has shown the existence of isotopes by means of the mass spectrograph there has been a desire to detect them by other means. Many ways have been attempted to show a physical difference in isotopes. The only way which has been successful is by means of the resolution of band spectra. The writer has recently shown the effect of isotopes in causing multiple bands in the case of the sulphates, the materials which did not have isotopes gave rise to only one band. Curves have been obtained which clearly indicate that nickel is made up of two isotopes, potassium has two and magnesium has three isotopes.

A Novel Design for a Gyroscopic Compass. A. H. PATTERSON.

Some years ago the writer was asked to investigate the value of a new form of gyrocompass. The main feature of the patent was the combination in one frame of two gyrorotors, set at an angle to each other. The claim was that in such a combination there was always an active torque on each rotor, the torques opposing each other when the frame stood exactly north and south, and when the frame drifted there was set up a sensitive differential torque which was more effective than the single torque on a single rotor. An investigation served to show that this claim was not well founded in theory, and was totally unpractical.

[1] This paper was printed in the Physical Review, Vol. 28, 1926.

The Histology of the Blood of Some Bermuda Ascidians. W. C. GEORGE.

This paper gave an account of the histology of the blood of the following species of ascidians: *Phallusia nigra, Ecteinascidia turbinata Clavelina oblongata, Symplegma viride.* There is very great variation in the structure of the blood cells of these species, but there appears to be an underlying homology of cell types.

CONTRIBUTIONS OF EXPERIMENTAL EMBRYOLOGY TO THE STUDY OF GERMINAL ORGANIZATION.[1]

By Bert Cunningham

Introduction

It is purposed today to review something of the efforts and achievements of the experimental embryologists, particularly as related to our knowledge of germinal organization. Embryology as a term is easily defined, but to express exactly the meaning of the experimental, as used here, is rather difficult. Embryology is the development of the adult from the sex cell or cells and it is more generally understood to relate to the earlier stages of development. For example, in the starfish, embryology is the development from egg to pluteus; in the frog, from egg to resting stage of tadpole which occurs before metamorphosis; in the chicken, from egg to hatching; in mammals, from conception to birth. While it is true that most of the embryological processes are completed within these limits, there are many cases in which the process is incomplete, as is the case of the tadpole, where glands such as the thyroid and sex glands do not reach their full maturity until during and after metamorphosis; and in mammals, man, for instance, where there is a recession of the thymus in childhood and the attainment of function of the sex glands during adolescence.

If embryology is considered as a study of the development of an organism from an egg, to make intelligible this process, it becomes necessary to collect consecutive "stages" and arrange them in orderly fashion. Such a study is purely morphological, depending upon collection of materials at proper intervals, the killing, fixing, staining, sectioning and the studying of serial sections of animals at different stages of their development. The greater the number of stages available, the more accurate will be the study. But even where multitudes of the same kinds of eggs have been studied by hundreds of students, there are many gaps in our knowledge. Books, such as that masterpiece of Lillie's on "The Chick," are bristling with question marks, due to this incomplete knowledge.

[1] Presidential Address, Twenty-Sixth Annual Meeting of the North Carolina Academy of Science.

Since no one can hope to see the process by which each vantage point in development is gained, one must be content to study each point and conjecture the route by which it was reached. Sometimes the stages are so close that little doubt can exist as to the route. Little by little the more difficult points are being connected by the discovery of those which are intermediate. In time, it is quite probable that every procedure of development will be cataloged.

It is this "How?" of development in which the general embryologist is most interested. Experimental embryology would go further and would seek to understand the "Why?" of this development. It seeks to understand, for example, why starfish eggs do not develop into sea urchins, and why dogs do not give birth to kittens; why appendages grow at the right moment, in fact, why they grow at all. This might be easily answered by saying that the eggs carry the characters of their ancestors, and that like begets like. On the face of it, this seems true, but there are many cases where the offspring of individuals are so different from parents that, to the unknowing, they would be, and, in fact have been conceived of as being, entirely different animals.

Embryology is morphological; experimental embryology is physiological. The latter could not possibly develop until the former had succeeded in cataloging the stages of development. Having found the morphological changes which take place in the developing animal, the experimental embryologist then seeks to discover the "why?" of natural development. This can often be determined by discovering what may bring about abnormal development. So all sorts of changes of environment are brought to bear upon the germ cells and developing embryos at all stages of their development, in the hope that some abnormality of development may arise which will give some hint as to the cause of normal development. Some of these results may be almost imperceptable. Others may be so spectacular as to attract at once the attention of even the uninitiated. Abnormal embryos once secured must be compared with the normals and the results must be correlated with the causes. In many cases this correlation is extremely difficult owing to numerous factors that may be involved.

Since most organisms arise from a fertilized egg, one would like to know if there is any organization in the germ cells which determines the direction of development.

By germinal organization is meant the definite arrangement of anlagen of tissues and organs in definite areas of the germ cell or cells, or, as defined by Whitman, organization is that "original constitution of

the germ which predetermines its type of development. . . . ." This is the question which receives our attention now.

PRE-FORMATION PERIOD

If embryology is considered the infant among biological sciences, then experimental embryology is a paedogenetic offspring. The interest of the human race in embryology must have been born in the dim dawn of our emergence. Nevertheless, we have but little, if any, record of real human interest in the method of development before the days of Aristotle. This many-sided philosopher and scientist observed phenomena which only more recent investigations have verified in the study of the embryology of the shark.

The earlier theories of development of the individual are largely tinctured with the idea that the embryo in all stages is more or less of a replica of the adult form. Aristotle, among others, thought that certain forms originated from mud by spontaneous generation, the originated animal having the appearance of the adult. However, he began some investigations upon embryology which would have borne entirely different fruit if he had had even a simple lens for his work. All Greeks were not so scientific as Aristotle and the impression of the general reader is that as a group, they believed in the assemblage by parts of individuals by super-human beings, much as the parts of an automobile may be assembled in the factory. Thus arose some of their weird creations of centaurs and mermaids. The conjectures of Empedocles, who is typical of this group, were put into verse by Lucretius, as follows:

> "Hence, doubtless, Earth prodigious forms at first
> Gendered, of face and members most grotesque:
> Monsters half-man, half-woman, not from each
> Distant, yet neither total; shapes unsound,
> Footless and handless, void of mouth or eye,
> Or from misjunction, maimed, of limb with limb:
> To act all impotent, or flee from harm,
> Or nurture take, their loathsome days t'extend.
> These sprang at first and things alike uncouth
> Yet vainly; for abhorrent *nature* quick
> Checked their vile growths; . . . . .
> Hence, doubtless, many a tribe has sunk supprest,
> Powerless its kind to gender. For whate'er
> Feeds on the living ether, craft or speed,
> Or courage stern, from age to age preserves
> In ranks uninjured: . . . .
> Yet Centaurs lived not; nor could shapes like these

Live ever, from two different natures reared,
Discordant limbs and powers by powers reversed."

It is strange that this author, who was the first to record actual observations on the embryology of animals, did not conceive of the origin of the individual as a developmental process.

That Aristotle was far in advance of his day is evidenced by the fact that no great student arose to carry on his work and continue his investigations on the development of the chick, the fish, and the mammal. It was not until the seventeenth century that another real impetus was given to the study of embryology.

This new age was based upon the development of the idea of using illustrations. Thus the work became largely descriptive, illustrated by drawing of the conditions observed. As a forerunner of this era in the development of embryological study, is a work accredited to Roger Bacon in the thirteenth century. Concerning this, Garrison, in his History of Medicine remarks as follows:

"A strange Ms of Roger Bacon's written either in Gaelic or cipher, full of remarkable naturalistic miniature figurations of pregnancy suggest some kind of esoteric or mesmeric magic like that of the Hindu fakirs."

Fabricius, in 1600,[2] published what is most generally recognized as the first figures of the embryology of the chick, mammal, and man, based upon observation. Four years later, Schüler published other embryological figures. Spigelius followed, with figures of the human foetus, and Needham, with figures of mammalian development. Harvey, a pupil of Fabricius, opened the second half of the century with his *Exercitations*. His direct scientific contributions are great, and his philosophy of the organism indicates that he, too, was far in advance of his time He expressed nearly the ideas of some modern students when he wrote "no part of the future offspring exists *de facto* but all parts inhere *in potentia;*" and "the germ is not merely a body in which life is dormant or potential, but it is a detached portion of a pre-existing living body."

With this work a new era of intensive investigation was initiated and a series of well known names follow. DeGraff discovered the follicle in the ovary; Swammerdan observed the cleavage furrow of the frog egg; Leeuwenhoek described and figured the spermatozoa which was really discovered by one of his medical students, Hamm. Ruysch figured the embryonic skeleton. The century was fittingly closed

[2] "Except the figures of Coiter (1573), those of Fabricius were the earliest published illustrations of the kind." Biology and Its Makers—Locy.

with the remarkable work of Malpighi on the development of the chick. The contributions of this group were made possible largely through the use of the simple microscope, which had just been invented. Like most new instruments, the microscope misled a number of workers, among whom were Ehrenberg, who thought he saw the internal organs of protozoa; Malpighi, who, observing the chick on the embryonic disk, mistook it for a replica of an adult; and Hartsoeker, who saw what he described and figured as a miniature human being in the head of a sperm. The observations and misrepresentations of the two latter were instrumental in carrying embryological thought back hundreds of years and lent much prestige to the idea that germ cells contain the adult in a miniature replica form. This idea became more fully fixed when cocoons of moths, which were mistaken for eggs, when opened, revealed adults just ready for emergence.

The conception that the animal exists in the germ cell as a replica of the adult is known as preformation. All that is necessary to produce the adult from such a form is growth in size with practically no modification of form.

If it were true that the animal exists in miniature in the germ cell and does not grow from a simpler origin, then the individual germ cell must contain within it not only the individual to which it gives rise, but, within that individual must be germ cells, and within those germ cells still other individuals and so on *ad infinitum*. This inclusion of egg and individual, one within the other, is commonly known as the "pill box" theory but more scientifically, as the "*emboîtement*" theory. It gained somewhat from the discoveries of paleontology which had produced fossils of extinct forms, some of which had been abundant at earlier times. Nothing could be more reasonable than the passing of a group of animals when the final box had been opened. Such natural explanation made the cataclysms as suggested by Cuvier, unnecessary for the elimination of forms.

It has been previously indicated that preformed individuals might be considered as existent either in the egg or in the sperm. The conception of preformation in the ovum antedated that in the sperm by many centuries, wholly because the existence of the sperm was unknown. When it was discovered, just before the close of the seventeenth century, it was first looked upon as a parasite in the seminal fluids. Its normality, however, was soon discovered, and in 1694, Hartsoeker, (who claims priority in the discovery of the sperm) attributed to the sperm the more important part of reproduction, in that it contained the individual in miniature. By means of his microscope, as already pointed

out, he thought he observed the human being. This conception gave rise to a new school, the spermists, who believed that the preformation existed in the sperm, as opposed to the ovists, who believed that preformation existed in the ovum. The more fantastic spermists figured and thought of the egg as a sort of house to be entered by a trap door. When the time was ripe, the sperms gathered around the portal and a grand mêlée ensued until one sperm gained entrance and barred the door. So great and terrible were these battles that often the loss of eyes or legs or arms was the price of victory. When such victors were safely housed within the ovum they grew to adulthood, but they bore their scars and were minus their lost members throughout life. Thus they explained the birth of various monsters. The spermists gained considerable ground when it was observed by Prévost and Dumas (1824) that filtered seminal fluids were impotent in development.

For the next half century the battle raged between the two schools without either group making a single important contribution to knowledge.

The latter half of the century, however, saw a revival of the investigative method, as is evidenced by the publications of Casper F. Wolff. His study of the development of the intestine proved that the animal was not preformed in the embryo, but arose as a sort of an evolution from the simple tissue layers to the more and more complex organization. In short, Wolff was reëstablishing the epigenetic idea which had found some slight recognition from Aristotle and others. While Wolff believed that a mixing of the germinal fluids was essential for development, he thought that development was more or less directed by what might be considered by some as an entelechy, viz., the *"vis essentialis corporis,"* which worked in the embryo.

The chief opponent of Wolff in his theory of development was Bonnet, who did not conceive of the embryo as quite a replica of the adult, but rather as a mass of structures closely packed together, which in growth, expanded and separated. The ensuing interspaces were filled by infiltration of foreign material, and thus the organism was a combination of frame work which was preformed and an infiltration of new material not previously existent in the egg. By this time, the idea of preformation had begun to waver.

PREDELINEATION PERIOD

The work of Wolff freed and stimulated the mind to further investigation, and in rather rapid succession follows the names of Oken, Meckel,

Pander and von Baer. Pander paved the way for the new era by describing the three germ layers. It is not evident whether he ascribed to each the definite anlagen of certain organs, but von Baer did give a description of the germ layers and listed more or less accurately the organs formed from each. He described four layers, mistaking the splanchnic and somatic mesoderm for two distinct layers.

With von Baer the real work of comparative embryology took its rise, and the high standards which he set have been scarcely surpassed by any of his successors. The germ layer theory became so firmly established that it has been shaken only in recent years. In addition to his work on germ layers, von Baer discovered the human ovum and differentiated it from the follicle, thus laying the foundation for the work of Gegenbauer, who in 1861, showed that all eggs are single cells.

von Baer's contributions were so numerous, so valuable, and so new, that he is considered as the founder of modern embryology. He is generally credited with having formulated the theory of recapitulation or the Law of Biogenesis, although the first clear statement of this law was made by Müller in 1863.

The discovery announced by Schleiden and Schwann, that animals and plants were of similar construction, in that they were all composed of cells, led to a new concept of the development of organisms.

Cleavage was observed in the frogs egg by Prévost and Dumas, and, in the fish, by Rusconi. The necessity of fertilization was discovered by Prévost and Dumas, although its real significance was not realized. Complex organisms were seen to originate from single cells by cell division. The germ layers were no longer considered as primitive anlagen while the importance of the germ cells grew until they engaged the center of thought. The nucleus was discovered and its significance was somewhat determined. Remak observed amitotic cell division in 1855. Then came the discovery of chromosomes by van Beneden and an appreciation of their significance in cell division and in heredity. Virchow conceived of germinal continuity in 1858. Contributions now came rapidly, and names of contributors can only be mentioned: Balfour, Hertwig, Fol, His, Roux, Herbst, Brooks, Minot, Whitman, Wilson, Morgan, Driesch, and others. Each added to the knowledge of the subject.

The field of experimental embryology was first clearly opened by His. By means of his simple microtome he was able to make many sections of embryos and thus was able to study more completely embryonic development. He was one of the first to conceive of the predelineation

in the germ cells, and he expresses himself thus; "The organs and parts of an embryo are represented in the early stages of development, perhaps even in the unsegmented egg, by definitely localized germ (anlagen). Here is a definite arrangement within the egg of definite particles which are to be qualitatively separated in the process of cleavage and differentiation of the parts of the body.

An intensive study was now made of the early cleavage stages to determine whether the process was quantitative, separating similar substances into each daughter cell, or whether it was qualitative, the daughter cells being dissimilar. This study of cleavage and later development led numbers of observers to see that certain cells in the early cleavage stages served as anlagen for definite organs, and thus there arose again the idea of preformation. Not the old idea of the adult replica, but rather a sort of spatial distribution of definite, possibly visible, particles which determined the ultimate function of the parts derived. These were separated out by a qualitative cleavage.

Such concepts as these must be based upon the idea that the egg has a definite orientation and a definite distribution of the anlagen within the germ cell.

That the egg has a definite orientation is doubted by few. The constant position of the egg of insects in the ovary, the location of the micropyle, the position of the polocyte in specific regions, the presence of definite animal and vegetal poles, the presence of restricted colored areas, and the restricted entrance point of sperms, all tend to indicate that the egg does have a definite orientation. But the acceptance of orientation does not necessitate the adoption of the idea of predelineation. Whether certain areas are the seat of the anlage of certain organs is open to experiment.

If there is a spatial distribution of definite anlagen of various tissues and organs, then these must be separated out sooner or later by cleavage.

When the anlage of an organ has been separated out by cleavage and the cell or cells bearing it have been removed from the remainder of the embryo, the adult, if development continues, will be without the organ represented in the anlage. Roux was one of the first to propose this idea. He found that if one of the blastomeres of the two cell stage of the frog were destroyed by a hot needle, the remaining blastomer developed only a half embryo. Thus he concluded that the very first cleavage of the frog egg was qualitative, separating the embryo into right and left halves. The theory based upon this observation is known as the mosaic theory of development, and, as expressed by Roux, the organism

is a whole, originating from a number of self-determining parts. Further experiment however revealed that if the uninjured blastomere of Roux's frog's egg were turned over, that it would produce a normal embryo, except for reduction in size.

It has also been shown by Schultz that if a frog egg is inverted after first cleavage, it will produce either two complete larvae or a double monster. These experiments indicate that each of the two blastomeres contain all the essential ingredients for total development, or that the first cleavage is not essentially qualitative.

Roux's work, although apparently proving just the opposite of what he first thought, served as a stimulus to further investigation by others who have been more fortunate in the selection of their materials. Morgan, with ctenophores; Wilson, with molluscs and annelids, and Conklin, with tunicates, have shown that removal of a blastomere gives rise to a defective larva, thus supporting the idea of a qualitative separation of organ-determinants in early cleavage.

Of an exactly opposite nature are the results secured by Driesch and others in their work on the sea urchin. As many as eight dwarf plutei may be formed from a single egg. Driesch therefore concluded that the blastomeres were equipotent, and that their ultimate function will be determined by their location. To him, as well as to Schleiden, "Each cell leads a double life; an independent one, pertaining to its own development alone; and another incidental in so far as it has become an integral part of a plant." Or, as expressed by Ryder, "The cell is a complete organism, but it loses its physiological and morphological autonomy when combined with other cells." Loeb, in his Physiological Morphology expresses himself as opposed to organization in the following words ". . . . of course, there must be a limit to the number of embryos that can arise from one egg: but the limit is not due to any preformation. . . . ."

The idea of qualitative cleavage can be further studied in the starfish egg by allowing cleavage of the fertilized egg to take place between glass plates. This will produce a flat plate of cells in which spatial relations of various cells must be abnormal, yet if the pressure is removed in time, further development will be normal. In a similar manner, eggs of the frog (Hertwig) which normally develop by holoblastic cleavage, can be made to adopt meroblastic cleavage by centrifuging without injury to further development. Embryos produced in this manner seem to be normal.

As further evidence against the organization theory, Driesch shows

that the type of cleavage has nothing to do with the origin of the ultimate organs, since the "primitive streak arises differently in the birds and mammals." Whitman holds that "the test of organization in the egg does not lie in its mode of cleavage, but in subtile formative processes." Further study of Whitman's writings leads one to believe that he holds to a sort of continuity of organization. . . . . "Comparative Embryology reminds us at every turn that the organism dominates cell formation," and "the embryonic mass acts as a unit tending always to assume the form peculiar to the state of development by its 'essential architectonic elements.'" These elements are not defined, and Nageli has said somewhat of the same thing without involving essential architectonic elements—"In the hen's egg the species is contained as completely as in the hen, and the hen's egg is as different from the frog's egg as the hen is different from the frog." This gives no concept of the why of development and one would do no worse by accepting Driesch's entelechy.

Investigators were not content to find that qualitative cleavage occurs, as is evident in many, though not all, cases, but desired to trace the predelineation back to the egg. The idea of the organization of the egg, which is synonymous with predelineation, was first proposed by Ernest Brück, in 1861. He conceived of the egg as made up of a large number of small parts. This idea was then largely theoretical and was probably more clearly stated by Darwin. It became decadent under the attack of Weismann, on a basis of the continuity of the germ plasm, but was revived by DeVries, in his "Intra-cellular Pangenesis." As expressed by Wilson in 1893, the theory holds that "every one of its (ovum) hereditary characters is, however, believed to be represented by definite structural units in the idioplasm of the germ cell, which is therefore conceived as a kind of microcosm, not similar to, but a perfect symbol of the macrocosm to which it gives rise (Hertwig)."

The problem of localization of certain factors in the egg for development of certain parts in the embryo is open to experiment. In many cases the egg can be definitely oriented either by the micropyle, by the distribution of yolk, by the location of polocyte and by the location of the nuclear spindle. When any two of these are present it is not difficult to make a topographical map of the egg. With the entrance point of the sperm determined, similar mapping may be more readily accomplished.

Having mapped the egg, one may proceed to remove fragments and study the effect upon the developing embryo, or one may study the

development of the enucleated fragments. One may also study the effects of all sorts of physical and chemical forces calculated to bring about abnormal distribution of the contents in the egg, and a resultant abnormal distribution in the blastomeres, or to bring about abnormal distribution of nuclei in daughter cells. One finds centrifugal force, pressure and gravity good agents for these studies. The distribution of anlagen in the nucleus and cytoplasm may also be studied by removing the nucleus or parts of the cytoplasm, and studying the further development.

By means of a Barber pipette, Chambers, Kite, and others were able to remove the nucleus without seriously injuring the cytoplasm. Slices of cytoplasm may also be cut away from the nucleus with sharp needles, but with more danger of injury.

If eggs enucleated in either manner are fertilized, they develop normally, showing that if organization exists in the nucleus alone it must exist in the sperm nucleus as well as in the egg nucleus.

If the enucleated eggs of *Sphaerechinus* are fertilized with sperm of *Echinus*, the characters will be largely paternal, showing the nuclear influence, but if the enucleated egg of *Echinus* be fertilized by the sperm of *Antedon*, the results indicate that the cytoplasm in this case wields a strong influence.

The normal yolk distribution in an egg can easily be disturbed by the centrifuge. For example, the eggs of *Arbacia* are red, due to the distribution of pigment granules. Lyon found that after centrifuging, this pigment arranged itself in four strata. These strata are perpendicular to the centrifugal force. Substances may therefore be shifted in relation to the original egg axis, and thus may be made to go into regions which are quite unnatural. Such procedure, however, does not interfere with normal development, and the conclusion is forced that in so far as these substances are concerned, cleavage is in no way qualitative.

The frog egg has a very definite polarity. With this and the entrance point of the sperm and the formation of the gray crescent located, definite localities of the egg can be determined. Earlier studies showed that the first cleavage plane passed near the point of the sperm entrance. Therefore, the egg was considered as an organized structure.

It is possible to change the axis of the frog egg by holding it in an abnormal position, or by use of the centrifuge, so it can not well be said that this axis is fixed; or, at least, not fixed until first cleavage has actually taken place. Even then, reversal of the egg will produce new axes, resulting in the development of twins or monstrosities. It is plain there-

fore, that one can hardly speak of a fixed, definite organization in the frog's egg.

If such organization did exist it must of necessity be flexible until fertilization has taken place, when it becomes fixed, or else it must be of such a nature that the sperm is able to gain entrance only upon a definite meridian. Experimentation by Clapp on the toad-fish eggs has shown that in this animal the first cleavage plane has no relation whatsoever to the yolk distribution, by which polarity is determined; hence, in this animal, the entrance of the sperm can in no sense be considered as a factor determining organization. Furthermore, frog eggs artificially activated by a needle show no relation of cleavage plane to the entrance point of the needle. Such cases as these indicate that the first cleavage is not qualitative. In a similar manner further cleavages of certain eggs indicate a delayed qualitative division.

As much as one would wish to reduce all life phenomena, as well as all cleavage processes, to a single category, these facts indicate that eggs are of two types, or, perhaps one should say, have reached different stages of fixation or organization. The star fish egg is highly regulative. That is, each blastomere up to the eighth cell is capable of regulation, or reorganization of its material if removed from the influence of its fellows. The frog egg is barely regulative and only so when disturbed by outside forces. Other eggs such as *Crepidula* may be wholly without regulative power. These conditions indicate different degrees of organization.

Regulation as used here is the reorganization of materials in the blastomeres so that a single blastomere may develop into a complete larva. Regulation must depend upon the retention in the cells of a portion of all the primitive materials. These become less effective in each blastomere if they are left in contact with each other.

Regulation in the egg or early blastomeres may be total or partial, depending upon whether or not the reciprocal influence of the blastomeres has been removed. If the blastomeres capable of regulation are completely separated in the two-cell stage, each reorganizes its materials, and each is capable of producing a complete embryo. This is total regulation. If the two blastomeres of the first cleavage of Triton be only slightly constricted at the first cleavage plane, a two-headed Triton may be produced. Conditions such as this may be explained on a basis of partial regulation. As cleavage proceeds, the power of regulation is rapidly lost so far as reorganization for the production of a whole organism is concerned, but many parts retain regulative power for

long periods of time, as is seen in the tadpole's tail. Conditions similar to this are to be discussed later.

Since, as has been shown by centrifuged eggs, the organization of the egg does not lie in its larger visible granules, it became necessary to postulate a rather rigid frame work of cytoplasm which was incapable of being moved by the centrifuge. This carries the factors of development in different regions. Such an hypothesis, of course, is unsatisfactory, since the frame work has not been demonstrated. Circumstantial evidence, however, in many cases tends to substantiate this theory, and Loeb conceived of cytoplasm as the "embryo in the rough." After the discovery of nuclear division Boveri considered the early cleavage stages to be controlled by the cytoplasm, and the latter development to be controlled by the nucleus.

With the discovery of the chromosome and mitotic cell division, the center of interest in organization was moved to the nucleus. A study of inheritance, which is too complicated to be explained here, has shown that certain regions of the chromosomes carry factors which determine eye color, or wing pattern, as the case may be. Here then is definite localization in the nucleus of a specific substance which is related to a definite form or structure. Studies of this type are necessarily restricted to measurable characters, and it is hardly fair to say that because a few factors are carried by chromosomes, all are. There are but few of these measurable characters in an organism. Wilson holds that "heredity is effected by the transmission of a nuclear preformation which finds expression in a process of cytoplasmic epigenesis." Boveri, as already stated considered the early development to be cytoplasmic and the later to be nucleic. In this he was not far from the ideas of Jenkinson, who believed the generic characters were transmitted by the cytoplasm.

The presence of factors in the chromosomes of the germ cells could in no manner explain the segregation of anlagen in cleavage since with the exception of the germ cells, the cells of all tissues have the same number of chromosomes in the nucleus, and there is no evidence to prove that their determinant composition is different in different tissues.

That the nucleus and the chromosomes are active in organization has been shown by fertilization of enucleated egg and a study made of their development. Egg cytoplasm without a nucleus cannot develop, but egg cytoplasm with a sperm nucleus can. Even the sperm nucleus is unnecessary in many cases if the cytoplasm has an egg nucleus of its own. If the nucleus alone is responsible for organization, then an

offspring should inherit approximately equally from each parent, since the nuclear materials are the only substances approximately equal in the sex cells from which the offspring arises. This is a necessary corollary of the nuclear inheritance theory, but it is denied by Guyer and Conklin, both of whom recognise both nuclear and cytological inheritance. There are therefore two definite schools of thought. One believes that virtually all inheritance, therefore all directive organization, is carried by the nucleus: The other holds that characters of genus and species are carried in the cytoplasm, but that the characters which make the individual closely resemble the parents and grand-parents are carried by the chromosomes; in other words, that organization is both nuclear and cytoplasmic.

There is evidence to support each view. Studies of Mendelian inheritance, and especially the work of Morgan on crossing over, the work of McClung, Morgan and others on sex chromosomes, leave no doubt but that chromosomes are concerned in the primary organization of the germ cell. The works of Conklin and others, have shown that the cytoplasm has to do with localization. Adding the two, one may therefore be justified in concluding that organization does exist; that it is both cytoplasmic and nuclear; that as cleavage proceeds, various factors are separated out and the anlagen become fixed in such a manner that they can proceed only onward to completion. The embryo, once it has set off an anlage, loses all power to replace it.

Continuously, throughout the embryological history, anlagen are set aside, these in turn produce new anlagen, and so on to the completed organism. Many anlagen retain a primitive character and are able therefore to replace lost parts and to repair injuries. For the most part, this is reduced to the minimum in higher animals.

These anlagen in some cases can be traced through cell lineage back to the egg cell, in many more, back to an early blastomere, thus indicating that there is an organization in the germ cell.

PREDETERMINATION ERA

The Predeterminationist does not look upon the egg as a bundle of preformed substances, each a definite tissue and definite organs; but rather as a chemical and physical configuration, which, once started, works out a definite sequence of stages, each based upon that preceding and giving rise to that which follows. No particular area of the egg is occupied by a specific substance, and such substances as exist are better thought of as physiological units, as suggested by Spencer, rather than as

the anlagen of His. Lankester, as early as 1877, suggested physiological molecules, which were not predelineated but were predetermined. In this case, the egg may be looked upon as a "reaction system" which drives on to a definite end unless interfered with. Guyer has conceived of the physiological units as similar to hormones or catalysers, which give rise to the new ones as development proceeds.

These ideas of interaction are rather fully supported by experimental evidence.

As has already been shown, both the nucleus and cytoplasm are incapable of independent development. Organization therefore can not be said to exist in either alone. Development evidently comes about as a reaction between nuclear and cytoplasmic materials under the influence of environment.

First cleavage shows the mutual interaction of the blastomeres, since they act differently if separated and allowed to develop independently. One is here caught on both horns of a dilemma; if the blastomeres are left together, the egg does not reorganise, if they are separated, they do reorganise.

Study of the later development shows rather conclusively that many tissues are not determined by their ancestral line, but develop a function in accord with their relative position. Lewis found that the optic cup of certain amphibians, if transplanted to foreign parts of the embryo, initiates lens development in the skin just over it. Jenkinson was able to inhibit the development of the optic cup by chemical means, and there was no lens development in the epidermis. This indicates rather clearly that lens development in these animals is a specific result of the influence of the eye cup. There is conflicting evidence, however, for the lens of *Rana esculenta* and certain fish differentiate independently of the optic cup.

It has been shown that where a portion of the spinal cord has been anterio-posteriorly reversed, that it proceeds in development to fit its new location. That which was anterior develops a posterior structure and function.

It has also been shown that substances produced in one part of the body have a very profound influence upon distant parts of the body. This is especially true of endocrine glands. Some of these secretions have been shown to be responsible for metamorphosis of tadpoles. Others have been used with varying degrees of success in the treatment of certain types of mental defectives; still others are used to stabilize the physiological processes during the climacteric.

It has been proven that growing tissues produce a growth producing substance which is not produced by the adult tissue. These substances, when applied to tissue cultures, have increased the growth rate tremendously.

All this leads one to believe that if there is an organization in the germ cell, it must be very primitive, and that the bulk of the development is directed by interacting systems.

THE VITALISTIC ERA

Because of the difficulties enumerated above, and since different eggs achieve their objectives by different routes, some workers, chief of whom is Driesch, postulate an entelechy resident in the germ which directs its development. All of the earlier preformationists were vitalists in the sense that there was a vital mechanism. The revolt against preformation led to a mechanistic conception of development, in which life is considered as the result of physico-chemical action, and not the cause of it.

The vitalists may be divided into two schools; i.e. those who believe that the egg is simply a part of a previous organism and that organization itself is transmitted, and those who believe that the egg is simply an inhibited organism which, due to environmental conditions, does not proceed to maturity.

That the egg is an inhibited organism, capable of reorganization of its substances, is indicated by the following facts:—

The egg, if properly released from its inhibition, will proceed to develop to the adult. This release may come about by natural fertilization, by natural parthenogenesis, and by artificial means such as cross fertilization by foreign or enucleated sperm, or by artificial parthenogenesis by chemical or physical means. Mechanical shock, penetration with a needle, treatment with chemicals, including dialyzates from sperms, and extracts of pollen are capable of releasing the inhibition.

More generally, the renewed activity of the egg, indicated by cleavage, is attributed to an inactivation rather than to a release from inhibition. If, however, the egg is a fully competent system within itself, as indicated by parthenogenesis, then its failure to continue its development is due to an inhibiting factor.

Since some eggs can be shown to be perfect organisms capable of complete development without fertilization, the entrance of the sperm complicates matters,—it brings a double nuclear organization. The egg organism is able to amalgamate this new organization and pro-

ceeds to the production of the complete organism as far as parts are concerned. But that there must be reorganization is evidenced by biparental inheritance, showing that some of the male organization has been accepted and, in fact, used to replace some of the egg organization.

We are confident that organization must exist in some manner in the germ cells; that it is not restricted either to the egg or to the sperm; that it is not limited to either the cytoplasm or the nucleus; that it is not an inflexible system incapable of change; that it is capable of amalgamating with other independent systems forming a unified whole.

Organization seems to be physiological in nature rather than anlagic in the older sense. The events of cleavage proceed as new organization of cells and new relationships arise. In the end the individual is a series of interacting parts, each more or less dependent upon the other.

Regarding the mechanics of localization, Wilson has said, "the mechanics of localization still present an unsolved problem" and the "existing mechanistic interpretation of vital phenomena are inadequate" and that "they are necessary fiction." Yet, this does not lead us to accept any entelechy which would prevent further experimental investigation of the organization of the germ cells.

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SOME DANGERS IN SPECIALIZATION

By Geo. W. Lay

The writer is only moderately up on theology and is not a scientist; but is in thorough sympathy with scientific thinkers. He ventures to hope that perhaps some thoughts appreciative of both sides would be in place at the present amusing and tragic crisis. His knowledge and experience are distinctly limited. Therefore he begs that any opinions or conclusions expressed be interpreted charitably as being offered modestly and subject to correction by wiser minds.

Science means knowledge; theology means the study of God. Each word would, on its first and etymological meaning, include all knowledge of every kind. Each however has been given a restricted technical signification, as is well understood. Each has its own particular and well defined field. The field of each borders on the other, has relations with it, and, in some respects, more or less involves it. For convenience I shall use theology in this paper to include all religious matters.

The complete mental life of both scientists and theologians as men is a different thing from that restricted mental life which they lead when occupied, each in his own specialty. The scientist *as such*, and in his own limited sphere of investigation (at present, at least, and excepting Sir Oliver Lodge) has nothing to say about the spiritual or of the ultimate origin of things. *As such* he ignores sentiment, aesthetics or the highest aspirations of our complete human nature. *As such* he neither affirms nor denies the existence of a Divine Creator. *As such* he has no theory as to how the natural universe came into being. He finds it in existence and takes it as it is and as it has been during countless, and yet finite, ages, since it came into being. He studies its qualities, its forces, the observed causes and their effects, and tries to bring the results of his observations into one coördinated body of knowledge. As a man however he should in his complete nature, go beyond the limits of his speciality.

A chemist may have to ascertain whether something put before him for analysis does or does not contain arsenic. The result will decide whether his best friend is guilty or innocent of murder. As a man one

would despise him if he did not feel tremendously the hope that the result of his analysis will justify his faith in his friend. As a chemist, engaged in a purely scientific investigation of ascertainable facts, he can give no place to sentiment or affection, important as they may be in him as a man worthy of admiration.

The theologian deals with God as revealed in His Word and in His Works; but primarily with the former. A really well versed theologian needs to be *in his own field* a more all round man in his sympathies with both fields than the scientist needs to be *in his own field*, and he is more apt to intrude ignorantly into what is beyond his knowledge. Both scientists and theologians are better men by taking as full cognizance as possible of both fields. Doubtless the shoemaker should stick to his last; but he will be better as a shoemaker, if he will be ever mindful of the feelings of those who are to wear the shoes.

The best scientists and theologians have in my limited experience some qualities in common. Each is well up in his specialty and modest in his estimate of the extent and accuracy of his knowledge in other matters. But each is eager to learn from the other and round out his knowledge as far as possible. Where they differ each respects the conscientious sincerity and honesty of the other. Neither would speak with disrespect of what the other holds in reverence, or use extreme or vituperative language in discussion on a point of difference. Of these men of the first rank the scientist would perhaps be more aloof mentally, since most of the people whom he meets know very little of that of which he knows everything that is known at that time. For him there exists the danger of not cultivating other interests and even of losing that appreciation which he formerly had. Darwin lost his earlier appreciation of music as well as his interest in religious matters, though both he and Huxley are quoted as speaking most reverently of the Creator. Any statement of a scientist is at once subject to the most thorough testing by hundreds of other scientists. Hence he is by nature slow to express a positive opinion. The theologian on the other hand is in great danger of making statements that are too positive and sweeping, since he is not likely to have anyone rise in opposition. Those of both classes have a distinct respect for authority in all spheres of knowledge.

At the opposite extreme is a vast horde of ignorant people who are not deterred from expressing a positive opinion on any subject by reason of their utter ignorance of it. Unfortunately this class is produced and encouraged more by religious teachers than by teachers of science, though the latter are not without offense. When a man is

taught that with the Bible in his hand he need seek no guide or teacher or consider any authority, it is not wonderful that he is led to think he he has a right to express an opinion on any subject, whether in science or theology. I know personally those who claim that the earth can not be round because the Bible says it is square, "Has four corners." With such it is useless to argue. They deny all authority, and yet their most original ideas are only a repetition of what they have heard from someone else. They are incapable of constructive thought, and, as someone has well said, when they think they are thinking, they are only rearranging their prejudices. The chief offenses of this class are committed in the spheres of medicine and religion, in which the most ignorant claims complete knowledge and expresses his opinion with an assurance of finality that out-popes the pope, though admitting no limitations such as safeguard the alleged infallible utterances of the bishop of Rome.

Between these two extremes there is a large class of ordinary, or garden variety, of scientific and theological thinkers and teachers. These are as a rule conscientious seekers after truth in their several specialties. Their danger is in so devoting themselves to their specialty as to become narrow in mental outlook and deficient in their appreciation of many things that make life interesting. Pride and prejudice may work them harm. Knowing more than most in certain subjects, they are liable to become over confident; and their concentration on one subject may prejudice them against the importance of other subjects.

And now as to the much talked of *conflict between religion and science.* This will always be, if we regard the phrase as indicating the inevitable necessity of readjustment in each sphere of thought as there arise new ideas and new ways of explaining or expressing the same old facts. There is always a conflict also between the different branches of science itself and between the science of today and the science of yesterday. Geologists, physicists and astronomers do not entirely agree, I believe, as to the age of this earth. Pasteur, like every other discoverer of a new truth, was vehemently opposed by leading scientists of his day.

Let me use an illustration. Suppose an object for our combined investigation. Let us call it the tree of *truth.* From its center we draw two lines at right angles to each other. The theological specialists are on one line, the scientific on the other. All are eager to find out all truth. Each party will see one quadrant of the tree of truth which the other can not see, one quadrant will be within sight of both, and another

quadrant will be beyond the sight of both. About some facts both will agree in the main, but with some slight difference due to their different points of view. With regard to some other facts each must get information from the other. But much is left that is unknown to all, and unknowable until they reach the end of the journey and pass beyond.

In each line those in front are the pioneers and discoverers of new knowledge. Those behind are slow to believe their testimony as to what they have discovered. The greater number are far in the rear and are largely occupied with disputing among themselves, rather than in directing their own eyes towards the tree of truth. The further they are off, the less interested they are in trying to see more clearly the truth itself. Those in the van in each party see more clearly and distinctly things unseen by the other, but the two are closer together. Thus I would illustrate the danger of being content with ones special knowledge and the advantage of sharing in the knowledge of others.

Another danger I would point out is that of demanding in totally different subjects the same kind of proof that one is accustomed to use in his own specialty. It is often stated that certain things cannot be proved, because they are not capable of mathematical demonstration where the opposite is absolutely inconceivable. Only in mathematics is such proof possible. In all the affairs of life, in the things we hold most dear and that mean the most in our lifes, our belief is based on cumulative evidence, extreme probability, beyond a *reasonable* doubt. If mathematical demonstration, or even strictly scientific evidence, were demanded as the only sufficient proof, it would indeed be a wise son who would know his own father, or even his own mother, except possibly in the case of a prince of the royal house of England. In different specialties, even in the different branches of science itself, different kinds of evidence are demanded. The evidence required by the paleontologist, for example, differs greatly from that demanded by the chemist. If the scientist in material things will admit that psychology is a science, he must at once enter an entirely new realm of thought. The old physics has turned over much that was formerly in its domain to the psychologist and the material and the psychical have joined amicably in the new science of physiological-psychology—a good example of the interdependence of different kinds of knowledge, and of the relation that should exist between the various specialties.

There is a danger to the special student in either the material or the spiritual that in his devotion to the one he may first ignore and then deny, the existence of the other. The scientist is in danger of denying

everything that cannot be brought under the scrutiny of the senses; the religious thinker is in equal danger of denying the facts of nature that are plainly evident to the senses. The one on seeing a giraffe for the first time may say, "They ain't no sich an animal," and the other may deny the existence and usefulness of sentiment, feeling, intuition, and the highest aspirations of the human heart; but the wise man will deplore the narrowness of the latter as much as the invincible ignorance of the former. Some of the greatest scientific discoveries have started with a "Hunch," which is another name for intuition. Alone it is not a proof, but it is a useful beginning. The senses may prove subject to illusions and hallucinations and the affections and sentiments may seem uncertain and hard to define; but it is only by using all our faculties that we can produce the completely cultivated man and come nearer to an understanding of the whole truth.

I venture to suggest two other dangers to which the scientist is peculiarly liable. First that he has plumbed the Infinite. It is so usual to speak of the infinitely great and the infinitesimally small, that there is danger of forgetting that these are purely figurative terms to express that which is beyond any adequate conception. Science has pushed back the limits of known time and space, but it never will attain of itself to a conception of the infinite. Its business does not reach the unlimited or infinite, though it makes more reasonable the idea of the infinite as a condition of thought.

The other danger is in speaking of nature as an intelligent personality. The universe is so full of the evidences of design that it is very difficult for the scientific writer to refrain from saying "Nature intended," or, "Nature has provided;" which of course scientifically is nonsense. If one believes that "In the beginning God created the heavens and the earth," we have an intelligent way of expressing the past and present working of a designing and guiding mind. Science *as such* has nothing to do with a First Cause, predicates no alternative and does not deny it.

I hope that you will not consider it out of place for me on an occasion like this to speak more or less as a theologian to you as scientists. You have been attacked, sometimes not gently or even charitably. On the whole you have been very patient under considerable provocation and have not replied in kind to some of the most violent of the denunciations. Keep it up. *Truth is mighty* and will prevail. Try to see the reasons for the position of those who differ with you. Leave a too familiar use of the terms "damnable," "hell" and "devil" to others.

Violence is an evidence of fear caused by lack of assurance of the certainty of one's position. Pity ignorance. Those who cannot state correctly the object of their attack are not likely to be very well grounded in what they are trying to uphold.

Scientists and theologians alike are seekers after *truth*. Happy is the man who finds it in both fields of knowledge. Only with both can one grow to the full stature of a man as he was intended to be. Science and religion, when rightly understood, help each other. Some of the noblest and most sincere minds have been those who sought for truth in science only. For what they were and did I admire and reverence them. But they missed a great deal. It is well to learn everything possible about the universe as it is and was; but it is a tragic pity to ignore the ultimate goal of life.

For myself I believe as surely as I do the truth of the multiplication table that one perfectly certain and safe course has been marked out for life's voyage. There may be other ways and other channels. One is sufficient and we have no business with any other possibility. We have been given chart and compass, and beacons plainly mark the right channel. The pilot stands beside each helmsman as he steers his own bark to the home port. There may be other channels by which one may reach the desired haven. I do not know. We have not been told more than was safely sufficient. Any unwise and reckless mariner who ignores chart and beacons to make doubtful trial of the unknown is left according to perfectly good, orthodox theology to the "uncovenanted mercies of God."

In the sailing directions that most of us try to follow there are two elements; the outward religious forms and observances which extend to the extreme of tithing mint, anise and cummin, and the weightier matters of the law, judgment, mercy and faith. Both are required. Many have omitted the one or the other. In either case they are off the prescribed course and are in danger of shipwreck. The two elements are supplementary to each other and not antagonistic. It is a mistake to neglect either, while exalting the other. There is at the present time much discussion as to the unwisdom of teaching mere religious observance and doctrine rather than a correct life. Properly stated it is a real danger. Either without the other is incomplete. Both are necessary. Neither the scientist who rests his faith on science alone without religion, nor the religious man, who leaves out charity to all, has followed the true course laid down.

Out of its connection I am sure to be misunderstood; but, with the

limitations of what precedes, and with the highest biblical authority, I venture to cherish the loving hope that, of those who have not rendered complete obedience, it will at the last be more tolerable for the honest, sincere and self-sacrificing seeker after *truth* in science than for the Christian Pharisee.

BEAUFORT, N. C.

A ZINC SPOT IN THE MARSH TEST

By H. B. Arbuckle and O. J. Thies, Jr.

Historical

Recently a case in which poisoning was suspected was brought to our attention. The nature of the case was such as to lead us to assume that arsenic, strychnine, or cyanide was the poison most likely to have been used. After due precautions of using special arsenic-free zinc, pure hydrochloric acid, clean apparatus, etc., followed by a satisfactory test that proved the reagents free from arsenic, some of the material to be tested was introduced into the generating flask. The diluting effect slowed down the reaction somewhat, so more pure acid had to be added. The gas was ignited, and cold porcelain held in the flame. A spot soon appeared. The test was positive, provided the spot was not antimony. Sodium hypobromite removed the spot; therefore it was not antimony. The belief is current, and is so stated in the literature, that arsenic and antimony are the only substances that produce the spots on cold porcelain in the Marsh's test. The only possible conclusion, then, was that arsenic was present.

Several large spots were obtained on a casserole, and were to have been saved for demonstration purposes. But the spots were not characteristic of arsenic; instead of being brownish black, they were bluish black; and after several hours they had disappeared! Arsenic spots are permanent. Something was wrong.

A search through the available literature for fallacies in the Marsh test yielded no information of any consequence. Wormley (1) suggests that organic matter, and certain combinations of iron, phosphorous, and sulphur may cause spots similar to those produced by arsenic and antimony, but does not consider difficulty from these sources worth consideration. Holland (2) states that chlorides, hydrochloric acid, nitrous compounds, or nitric acid might interfere with the Marsh test, but no suggestion is given as to the nature of the interference. Taylor (3) states that a liquid containing antimony, selenium, phosphorous, sulphur, or some kinds of organic matter may produce some kind of stain, or spot, in the Marsh test, but he concludes that the only inter-

ference of any practical force is that based on the presence of antimony. Blyth (4) suggests that a solid hydrate of arsenic may be formed and deposited on the surface of the zinc if nitrous compounds or nitric acid are present; he states that this difficulty can be overcome by the use of stannous chloride in hydrochloric acid, but adds that the presence of chlorides and of hydrochloric acid is not desirable. The only spot producing substances he recognizes are arsenic and antimony. The literature in general mildly criticizes our method, in that hydrochloric acid is not used as often as sulphuric acid, although hydrochloric acid gives good results when arsenic *is present;* and in that a calcium chloride tube is recommended, but is recommended for the specific purpose of thoroughly drying the gases evolved. It should be recalled, however, that the water produced by the combustion of the hydrogen is comparable in quantity with that carried by the undried gases; and, further, that satisfactory arsenic spots can be obtained when the gases have not been dried.

We can find no evidence, then, to the effect that a zinc spot has ever been observed in the Marsh's test.

Experimental

I. Pure zinc was introduced into a 125 cc. conical flask fitted with stopper, thistle tube, and jet tube; hydrochloric acid was added until vigorous action resulted. The hydrogen was ignited, and distinct blue-black spots deposited on porcelain held in the flame. Following this, several samples of reagents were tried in the same way, with the same result in each case; this eliminated the possiblity of the particular results being given by some contamination of some one bottle of reagent. The spots produced as stated above were removed by the reagents which dissolve arsenic spots, that is by ammonium sulphide, by sodium hypobromite, and by concentrated nitric acid. All indications were that the C. P. B. A. hydrochloric acid and the C. P. Special Arsenic-free Zinc were giving arsenic spots.

II. A 15 cm. straight drying tube filled with 4 to 6 mesh calcium chloride was connected to the hydrogen generator, and the escaping gas ignited. Spots were again obtained on the cold porcelain, but were obtained with considerably more difficulty; evidently the drying tube was acting as a kind of filter, and was partly removing from the gases that which was causing the spots.

III. Similar experiments were performed using the same apparatus, without the drying tube attached, substituting sulphuric acid for the

hydrochloric acid, then substituting hydrobromic acid, and finally, a mixture of hydrobromic and sulphuric acids, so as to give a very vigorous reaction, but no spots were obtained. These results proved the zinc free from arsenic, but beyond this, the information gleaned was of little consequence. After this, the same test was tried using magnesium as the metal, with the hydrochloric acid used in the first experiment; the failure to obtain a spot with this combination proved the purity of the hydrochloric acid.

The behavior of the zinc-hydrochloric acid combination is thus shown to be exceptional; it raised some pertinent questions: What is this spot? Zinc? Can zinc chloride be carried over mechanically, even through a long drying tube, by the rapidly escaping hydrogen? And if the answer to this question is *yes*, then, is the reaction

$$Zn + 2\ HCl \rightarrow H_2 + ZnCl_2$$

reversible?

IV. Proof of the mechanical projection of zinc chloride. The gases from the above described apparatus, charged with zinc and hydrochloric acid, with drying tube removed, were led into dilute ammonium hydroxide for several minutes. The presence of chloride was demonstrated in a portion of this solution by acidifying and adding silver nitrate. Another portion of the ammoniacal solution gave a slight turbidity with ammonium sulphide reagent, indicating the presence of zinc. The third portion of the solution was carefully evaporated to about 0.5 cc., made slightly acid, a drop of this treated with a drop of potassium mercuric thio-cyanate reagent ($KHg(CNS)_3$) on a microscope slide, and examined with low power lenses. The unique and beautiful crosses characteristic of zinc mercuric thio-cyanate ($Zn(CNS)_2 \cdot Hg(CNS)_2$) (5) soon appeared; thus the presence of the zinc ion was established, and the mechanical projection of zinc chloride proved.

V. By an analogous experiment it was shown that zinc sulphate was not carried over, and it naturally follows that zinc bromide is also not carried over mechanically, since neither sulphuric nor hydrobromic acid gave spots on porcelain.

VI. The composition of the spots. The spots on porcelain were found to be soluble, with the evolution of gas, in hydrochloric acid; this, with other information from the preceding experiments, led us to test for zinc. A spot was dissolved in dilute acid, and treated with potassium mercuric thio-cyanate reagent; zinc mercuric thio-cyanate crystals formed. This test, with the evolution of gas when the spot dissolves, and the color of the spot, identify it positively as metallic zinc.

VII. How is zinc liberated from the zinc chloride? Is the reaction between zinc and hydrochloric acid a reversible one? To answer these questions, a stream of dry hydrogen was led over zinc chloride heated in a hard glass tube. The issuing gases were ignited, and porcelain held in the flame. Enormous zinc spots were obtained at once. After the heating of the hard glass tube had been continued for ten to fifteen minutes, a distinct metallic mirror had formed at a constriction in the tube. Some vaporized zinc chloride had also deposited in the constriction; to test the metallic film for zinc, it was necessary to carefully remove it from the glass, wash and dry it, dissolve it in dilute acid, and apply the potassium mercuric thio-cyanate test. As would be expected, the mirror was found to be metallic zinc. When heated alone, zinc chloride volatilizes without decomposition, but in the presence of the hydrogen, it is reduced to zinc, and the hydrogen is oxidized to hydrogen chloride, according to the reaction:

$$ZnCl_2 + H_2 \rightarrow Zn + 2HCl$$

VIII. Thus far, only the original Marsh test method has been considered. To determine whether a zinc spot, or mirror, would be obtained in the Berzelius modification, a constricted hard glass tube was connected directly to the generator used in experiment I, the generator charged with hydrochloric acid and zinc, and the tube heated back of the constriction. A metallic mirror soon appeared at the constriction; along with the mirror was formed a grayish-white film. The metallic mirror was shown to be zinc, and the grayish-white film to be zinc oxide.

IX. Distinction of the zinc spots and mirrors from arsenic and antimony spots. The latter are not attacked by dilute acid; the zinc spots are readily dissolved by dilute acid. Thus the presence or absence of zinc can be determined with ease.

DISCUSSION

The most remarkable feature connected with this study is the apparent absence of any reference to it in the literature. The failure of sulphuric and of hydrobromic acids, respectively, and mixed, to produce zinc spots is interesting, and fortunate. The only suggestion proposed to account for this difference is that the sulphate and bromide of zinc are somewhat heavier than the chloride, so far as molecular weights are concerned, and therefore may not be projected as readily as the chloride is; this explanation, however, does not appear to be satisfactory. If the

zinc chloride were carried over with the hydrogen as a vapor, due to the vapor pressure that the zinc chloride exerts, then the bromide would be carried over in larger quantity, since it has the lower boiling point, and consequently the higher vapor pressure. The failure of sulphuric acid to give zinc spots is quite fortunate, for it leaves the analyst an acid which he knows will lead him to no false conclusions in his tests for arsenic and antimony.

Attention should be called again to the reaction between zinc chloride and hydrogen. The reaction between zinc and hydrochloric acid is usually considered an irreversible action, but it is seen above, that, by properly altering the physical conditions, it can be reversed.

The fact that the zinc spots dissolve in the three reagents most frequently applied to distinguish arsenic from antimony makes it imperative that, when chlorides are present, the deposit be tested first with dilute hydrochloric acid.

SUMMARY

1. Zinc is found to produce a spot similar to those given by arsenic and antimony when zinc and hydrochloric acid are used in the Marsh apparatus for detection of arsenic.
2. The zinc spot is not produced when sulphuric acid is used.
3. The zinc spot and the arsenic spot are differentiated.
4. The reaction, $Zn + 2HCl \rightarrow H_2 + ZnCl_2$ is found to be reversible.

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THE STATUS OF CHEMICAL INDUSTRIES IN NORTH CAROLINA IN 1926—III

By Frank C. Vilbrandt

Recent statistics have placed North Carolina among the first ten states of the United States in industrial wealth. Many factors have contributed to this state's progress along industrial lines, no single condition being alone responsible. In this progress the chemical industries have maintained a growth, contributing as much as the two leading industries, cotton and tobacco, and more than the others. The capital invested in the chemical industries is probably as widely distributed among native and out-of-state investors as any one of the six ranking industries. The labor is practically 100% native. Some of its products are providing serious competition in other states, one of them having no serious rival; this contributes greatly toward bringing into the state wealth and capital for further developments.

This survey of the chemical industries of North Carolina is the third of a series made for the purpose of recording the progress and development along chemical lines. The first of these surveys was made in 1922 (Journal of the Elisha Mitchell Scientific Society XXXIX, 76, 1923); at that time the remarkable growth of the chemical industries of the state during the past decade was noted. Further rapid expansion was predicted at that time. The second of the series was made in 1924 (Journal of the Elisha Mitchell Scientific Society XLI, 115, 1925). The two year lapse between the first and second survey was attended by a decided check in the rapid development, a retrogression, although the volume of business was still double that of a decade previous to that date. Kindred depression occurred in the cotton and knitting milling industries, not only in capital invested but also in the value of products.

This third study of the chemical industries of North Carolina shows an increase in the number of plants and value of products over two years ago, but not equal to that of four years ago. Also there has been a decided turn toward consolidation, the erection of new and larger plants and the elimination of many of the very small factories. The latest statistics for 1926 show that there are 394 chemical plants employing 12,087 people, who receive in wages $11,836,550 for producing

TABLE 1

RATING OF MANUFACTORIES IN NORTH CAROLINA IN 1926

INDUSTRIES	CAPITAL INVESTED	ESTIMATED PLANT VALUATION	ESTIMATED PRODUCTION VALUATION	ANNUAL PAYROLL	EMPLOYEES	NUMBER OF PLANTS
Cotton mills	200,000,000	310,000,000			83,518	406
Tobacco plants	240,557,600	33,582,000	272,643,400	16,621,300	20,465	9
Chemical industries:						
Fertilizer and scrap	38,429,500	24,738,300	8,361,000	1,088,700	957	27
Cottonseed products	4,151,900	4,011,200	15,657,600	761,200	1,345	29
Leather	6,490,000	4,841,900	10,381,000	1,045,400	1,143	10
Paper pulp, etc	4,014,000	4,030,000	10,166,500	2,507,000	1,686	2
Food products	4,106,000	2,683,600	6,639,000	793,800	575	42
Rubber products	4,300,000	1,185,500	4,300,000	471,000	428	3
Manufactured ice	2,322,125	3,207,300	4,399,300	1,361,800	746	40
Ceramics	1,999,200	2,367,000	3,361,500	1,100,200	1,477	53
Textile finishing	1,869,600	2,629,900	7,274,600	958,400	1,304	12
Proprietory drugs	1,041,500	487,750	2,303,000	241,700	254	8
Laundry	1,220,900	1,851,600	2,157,500	1,087,000	1,479	25
Paint, shoe cleaner, etc	984,700	548,000	1,852,000	337,000	631	7
Gas	589,600	282,100	995,500	77,350	50	8
Minerals			10,699,500			127
Turpentine, Rosin and Pine oils	50,000	150,000	100,000	6,000	12	1
Chemical totals	71,569,025	52,514,150	88,648,000	11,836,550	12,087	394
Knitting mills	34,129,500		37,359,000		13,663	129
Furniture factories	16,182,200	15,003,400	55,710,000	10,856,200	17,933	109
Woolen, silk and cordage	5,995,600		14,644,900		3,004	21
All others (Garages, lumber, feed mills, etc.)	318,792,175	31,542,600	122,174,500	24,296,950	26,072	881

$88,648,000 worth of products in plants valued at $52,514,150, which industries have been capitalized at $71,569,025. In capitalization the loss since 1924 has been twenty-six million dollars covered by consolidation and the elimination of excessive duplication of wasteful effort. The above data do not include all the statistics, inasmuch as the totals on water purification plants and the gigantic alumina reduction plant of the Tallassee Power Company at Badin were not available. Several large projects have been initiated during 1926 that will not show production data until later. In addition separate data on the finishing plants in the cotton mills could not be obtained.

The enormous sums credited to tobacco and cotton industries capitalization overshadow that of the chemical industries, but in tangible,

TABLE 2

PROGRESS IN NORTH CAROLINA INDUSTRIES IN 1922, 1924 AND 1926

INDUSTRIES	CAPITAL INVESTED (IN MILLIONS)			ANNUAL PRODUCTION (IN MILLIONS)			EMPLOYEES (IN THOUSANDS)			PLANTS		
	1922	1924	1926	1922	1924	1926	1922	1924	1926	1922	1924	1926
Cotton mills	$200	$168	$200	$285	$252		74	84	84	405	386	406
Tobacco plants	130	110	241	225	252	$272	9	17	20	23	17	9
Chemical industries	120	98	71	207	68	89	11	11	12	362	337	394
Knitting mills	31	34	34	33	29	37	17	13	14	175	131	129
Furniture factories	16	13	16	40	42	56	14	11	18	124	99	109
Woolen, silk and cordage	5	6	6	6	8	15	2	2	3	14	17	21
All others	455	162	319	47	199	122	60	43	26	5,270	1,735	881

taxable property, the latter excels that of tobacco. On the basis of capital invested, the chemical industries bring a greater percentage return in value of products than tobacco, knitting mills and miscellaneous industries. Furniture factories with a ratio of 16/55 rates the highest; woolen, silk and cordage plants with 16/40 are next; then comes chemical industries with 16/22, tobacco with 16/17, knitting mills with 16/17, and miscellaneous industries with 16/6, cotton not included on account of lack of production data.

The ranking for the ratio of capital invested to plant valuation is as follows: cotton mills—16/25, furniture factories—16/15, chemical industries—16/12, tobacco plants—16/2, miscellaneous—16/2.

A comparison of the changes that have taken place in the various industries since 1922 is given in table 1. Chemical industries hold

firmly to third position. The rating of the manufactories of the state for 1926 is presented in table 2. A brief survey of each of the classes of chemical industries is given in the following discussion.

FERTILIZER

The fertilizer industry is located primarily in the Piedmont and Coastal sections of the state. At the present time much of this essential agricultural commodity is being shipped into the state, the state plants making only 16 per cent of what is consumed; the total fertilizer bill for the state amounts to $50,000,000, exclusive of fish oil and fish scrap. With the recovery of the Virginia-Carolina Chemical Company the fertilizer industry can look forward to more fully satisfying the demands from the plants in the state. The fish scrap and fish oil division had a poor year due to poor catches; it was able to readily dispose of its stock. In 1926 this industry rated but one-half million dollar business, while in fair seasons it can expect a million or better. One fertilizer and three fish scrap and oil plants registered below $100,000 and six fertilizer plants above $500,000 in value of products. A 260-day year prevails n the fertilizer division and a 135-day year in the fish scrap and oil.

COTTONSEED PRODUCTS

The slump in the cotton industry has made its impression on its by-products, viz. cottonseed oil production. Rayon is causing trouble in the cotton milling industry and will probably do likewise to the oil. New methods of refining will then be necessary to augment the demands by utilizing poorer oils or cotton may be developed for its oil as is done in linseed oil industry. All but one cottonseed oil plant produced over $100,000 worth of oil last year, while six of them produced over $500,000. A 220-day year prevails in this field.

LEATHER

The leather industry is located in the mountain region of western North Carolina, where there exists an abundance of soft water, local tanning materials and isolation from dense centers of population. Most of the capital invested is out-of-state; the hides come mainly from South America. A 280-day year prevails in the ten plants; seven plants handle over $500,000 worth of material and only two handle less than $100,000 worth.

PAPER AND PULP

Only one plant is at present operating for the manufacture of paper, pulp, and by-products such as tanning extract, caustic soda, spruce turpentine, road binder, etc. This plant is located in Canton in Haywood County in the mountains of western North Carolina. Over $6,000,000 worth of products were made last year. The fabrication of carton and box board is receiving some attention in several localities.

FOOD PRODUCTS

Very little canning is done on the commercial basis in this state. The food industries include cheese factories, creameries, ice cream plants, canneries, cereal plants and meat packing houses. Only fifteen of the 42 plants handle less than $100,000 worth of products and twenty-one more than $500,000. An average 350-day year prevails in these industries.

RUBBER PRODUCTS

As the number of automobiles in the state mounts, the demand for tires will also increase, which demand should be met by tires made in the state. The quality of the tires produced is of the best although it suffers by comparison because the industry here is smaller and cannot use the same advertising tactics that the large northern factories can resort to. Various sizes of tires and tubes are made in the three tire and tube plants. The largest plant in the state is located in Charlotte; all the plants produce over $500,000 worth of tires and tubes a year. The plants operate on a 270-day schedule.

ICE

The demands for this commodity have doubled in the last two years although there are fewer plants now. Six of the 40 plants had an annual production of over $100,000 while 15 were below $25,000. With the more wide-spread use of household refrigeration plants, a decrease in the smaller plants will result. Three large corporations are constructing new plants in the state which will also tend to eliminate the small producer.

CERAMICS

Under this caption are included pottery, tile, terra cotta, brick and concrete specialties. The pottery division consist of very small plants,

with the exception of the new North State Pottery Company of Sanford. The above company and its products are not as well known as the smaller Hilton Pottery of Hickory. The Pomona Terra Cotta and Tile Company is the largest ceramic plant in the state. Some excellent brick are now being made and the average grade of product for the state has been greatly increased by the cessation of operation in the multitudinous little brick plants that at one time were scattered over the state. The 53 plants are divided as follows: 31 produce less than $25,000 worth of ware, 18 between $25,000 and $100,000 and 4 over the last figure. In these plants 205 days constitute the working year.

TEXTILE FINISHING

In all the chemical industries, none have achieved in the last four years the progress enjoyed by textile finishing. At present there are 12 mills, 8 of these handling over $200,000 worth of business. The Proximity Print Works with a production of $3,000,000 worth of prints and vatted materials, the Elmore Company of Spindale with a million dollar mercerized materials turnover, and the National Dye Works of Burlington, which handles over $531,000 worth of custom business, are the leaders in the field. Data is lacking for the other finishing plants in the state. Also in connection with many of the cotton mills, there are bleacheries, dye and finishing plants, the data thereof being included in that of the cotton mills, padding the figures of the latter at the expense of the chemical industries. Under such circumstances the data given is far less than the true amount involved in textile treatment. It is gratifying to note the progress made in this industry and the increased capital invested in this, one of our own industries, since cotton finishing should be done in North Carolina and not sent out of the state.

PROPRIETORY DRUGS

There are but eight firms in the state making proprietory drugs, but only three of these can be classed as industries. The nationally known Vick's Vaporub leads this field, this production amounting well over $1,550,000 in 1926.

LAUNDRY

Recent progress in laundry has been due to the efforts and investigations of chemists, and this industry is coming to depend more and more upon chemistry for assistance in increasing the quality of work and the

efficiency of the plant. The early demise of the negro servant laundry is predicted in the rapid expansion of the laundries in the state. The state now boasts of 25 laundries with only 5 handling less than $25,000 worth of business, while 7 did better than $100,000. An average 300 day-year prevails in the laundry industry.

PAINT, SHOE CLEANER, MISCELLANEOUS

The Nu-Shine Company of Reidsville has a very large interstate business; hardly a shoe store east of the Mississippi River is without it. The paint plant located at Wilmington is small. The manufacture of cleaning compounds and the treatment of timber by creosoting constitute the remainder of this miscellaneous class.

GAS

The gas industry is essentially a municipal affair, although not all the plants are municipally owned. The value of gas sold among the eight plants ranges between $14,000 and $52,000. The use of gas for domestic purposes is not very common, since the high gas rate prevents many from using this efficient heating material. Included in the data for the gas plants in the table are two Pintsch compressed gas plants, located at Rocky Mount and Greensboro.

WOOD TURPENTINE AND ROSIN

Only one plant, The Spirittine Chemical Company remains of the big industry that once existed in this state, but which died with the march southward of the industry into the more prolific forests of Georgia and Florida. Just to what extent synthetic chemicals will affect this industry will not be known for a few years, but carelessness, fires, hogging and improper cutting have done their share towards killing the recent estate workings. No estate operations were reported in 1926.

MINERALS

It is reported that there are 127 actual operating mines in the state producing a variety of minerals, such as kaolin, iron ore, copper ore, quartz, quartzite, feldspars, granites, limestone, coal, shale, talc, pyrophylite, gold and silver. Over $10,000,000 has been realized from these operations. Gold and silver operations are being conducted in Stanly County, Coal in the Deep River Valley, mica, feldspars, granite, lime-

stone, talc, pyrophylite, granite, quartz and gravel from western North Carolina. Data on the financial side of the mineral developments is lacking.

HYDROELECTRIC POWER

One of the governing influences in the further development of the chemical industries of North Carolina is the presence of the vast but limited water power. Of the total of 590,000 horsepower developed by water power, energy from about 111,000 horsepower or about 18.8 per cent is transmitted for use outside of the state. 119,000 horsepower, or 20.2 per cent is used at Bain for the reduction of alumina, and 22 per cent sold to public utility companies for resale for general use, leaving 39 per cent available for industrial power use in textile, flour, feed, knitting mills and the like. North Carolina ranks fourth among the states in the magnitude of developed water power and also in undeveloped water power in the United States. Work toward the development of 83,000 horsepower on the Yadkin River near Norwood, 40,000 on the Yadkin at Highrock, 35,000 on the Big Pigeon River in Haywood County is being carried on at present.

STEAM POWER

With its wealth of hydroelectric power, North Carolina is not losing sight of the advantages of steam power projects, as noted by a total of 470,150 horsepower developed by this means in 1926.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

INSULATION FOR REFRIGERATORS

By W. C. Hammond, Jr., and F. C. Vilbrandt

The selection of the material to be used for insulation in the walls of a household and a commercial refrigerator depends upon the cost of the material and upon its specific insulating qualities. The cost of the material is not the primary determining factor in the household refrigerator, since this is but a small percentage of the investment. However, the cost becomes paramount when linings for commercial refrigerators are considered. Nevertheless, there does exist such wide differences in the insulating characteristics of the various materials that consideration must be given such characteristics. Also, the cost of operation of the present day household refrigeration plants depends primarily upon the amount of heat losses through the walls. Therefore, the selection of the proper insulator and the most economical thickness of material to be used has considerable importance.

An investigation was made on a few common insulating materials, with the purpose of rating or ranking these materials in the order of their specific insulation qualities.

The equipment consisted of a well-known nationally advertised refrigerating unit with a home made ice chest, the latter being made in the laboratories of special design so that the top, front, back and sides could be filled with the different materials studied. In addition the inner walls of the sides, front and back were adjustable to two, four and six inch thicknesses, the top remaining at four inches.

The series of studies were made by setting the inner walls at a given distance and filling top, back, front and side walls with one of the insulators. Thermometers were placed at different points in the box, one in the ice chamber, one against the inner wall on each side, two in front and one in the top; other thermometers were placed directly against the outside wall, thereby obtaining the temperature drop through varying thicknesses of materials.

In order to eliminate outside influences as much as possible, the tests were made during the winter months, when the heating system of the Department of Chemistry was in operation, this system operating

automatically to keep the temperature of the rooms between 22° and 25°C. Also, the refrigerating unit tended to keep the inside refrigerant at the same temperature, operating automatically by pressure release and contact of the electric switch operating the motor driving the compressor.

TABLE 1

INSULATOR STUDIES

MATERIAL	CONDITION OF MATERIAL	THICKNESS OF WALL	ROOM TEMPERATURE	TEMPERATURE OF ICE CHEST	ICE BOX TO INNER WALL	INNER WALL TO OUTER WALL	OUTER WALL TO ROOM	AVERAGE RUNNING TIME OF COMPRESSOR
		inches	*°C.*	*°C.*	*°C.*	*°C.*	*°C.*	*min./hr.*
Sawdust	Dry	2	22.9	3.4	6.8	5.7	2.0	23
	Dry	4	22.7	3.4	6.2	7.9	2.2	22
	Dry	6	22.0	3.0	7.3	8.4	2.7	18
	Wet	6	22.7	3.3	6.9	10.4	3.1	18
Shavings	Dry	2	22.3	3.9	6.2	8.9	2.3	19
	Dry	4	21.6	3.5	5.9	10.2	2.0	15
	Dry	6	22.8	3.5	4.8	10.6	2.9	12
	Wet	6	22.2	3.7	6.5	9.7	2.3	13
Cotton	Dry	2	23.9	3.0	5.8	7.7	3.4	19
	Dry	4	23.5	3.1	5.8	11.6	2.0	13
	Dry	6	23.3	3.3	5.5	12.5	2.0	12
	Wet	6	23.0	3.1	6.6	11.6	2.7	14
Asbestos	Dry	2	25.3	5.0	5.8	9.1	5.4	14
	Dry	4	25.1	4.5	5.5	11.1	4.0	13
	Dry	6	25.0	4.5	5.7	13.3	4.5	12
	Wet	6	24.9	4.5	5.4	11.0	4.0	15
Brick	Dry	2	24.0	8.3	4.2	3.3	8.2	29
	Dry	4	24.9	9.0	4.3	3.4	9.2	29
	Dry	8	24.6	7.4	6.2	3.4	7.6	25
	Wet	8	24.5	8.0	4.5	2.6	10.4	26

Wet and dry bulb measurements were also taken but these seemed of little value in as much as the humidity was essentially saturated. Readings read from 91.5 to 100 per cent throughout the tests.

The insulators were changed the night previous to a run, giving a full twelve hours for the equipment to come to equilibrium. The fair uniformity of readings over the next eight hours showed that this

time was ample for reaching the equilibrium before an investigation was made.

The duration of the running time of the compressor, which operated automatically was taken to determine whether this could be used as an index of the efficiency of the insulators.

In all, thirteen thermometers were distributed over the ice box, readings taken every half hour and over a period of eight hours. These readings were averaged to get the average temperature difference between the ice chest and the inner wall of insulator, between the inner wall and outer wall of insulator and the outer wall of insulator and the room. Curves were drawn over the eight hour period to show uniformity or lack of uniformity of results.

TABLE 2

RANKING OF INSULATORS

	TEMPERATURE DROP	
	°C	
1	12–14	Asbestos (6 inches), cotton (6 inches).
2	10–12	Cotton (4 inches), cotton (wet 6 inches), asbestos (4 inches), asbestos (wet 6 inches), shavings (6 inches), sawdust (wet 6 inches), shavings (4 inches)
3	8–10	Shavings (wet 6 inches), asbestos (2 inches), shavings (2 inches), sawdust (6 inches)
4	6–8	Sawdust (4 inches), cotton (2 inches)
5	4–6	Sawdust (2 inches)
6	2–4	Brick (all)

The insulators studied in this investigation were, wood shavings, sawdust, cotton, brick and 85 per cent magnesia asbestos. Walls of two, four and six inches, dry, and six inches with the insulator wetted down were used to find the effective ranking of the various insulators.

The readings of the thermometers were averaged and the averages from each half hour period were averaged for the eight hour period. The results so obtained from the different insulators investigated are given in table 1.

It is observed from the data that the ice chest temperature remained fairly constant at approximately 3.5°C. except with the brick, wherein losses were very pronounced, as evident by the necessity for the compressor to be operating approximately one half the time. The room temperature did not vary sufficiently to influence the results.

The retaining and shiftable walls for the insulators as well as the rigid exterior of the ice box were of common yellow pine. The wood material was of $\frac{1}{8}$ inch thickness throughout. Columns 6 and 8 show how effective this wood panelling served as an insulator. In the case of the inner wall the decrease in temperature approximated 5.5°C. while the external wall around 3.0°C. These values are greater than that for the 8-inch thickness of brick. Column 7 contains the data showing the effectiveness of the different thicknesses of the several materials studied; it gives the average differences in temperature registered on the thermometers on the opposite sides of the wall of insulator.

Ranking of efficiences of the different insulators and different thicknesses of insulators can be made from this column. In this column is contained the data on the equipment where changes were made while in all others no changes in equipment were made and the readings should have been fairly uniform except where a great difference in room temperature would affect the entire plant.

The ranking of the various insulators is given in table 2 in groups to allow for error in experimentation.

Arbitrarily calculated according to the above ratings asbestos rates 8, cotton 9, shavings 10, sawdust 15 and brick 24. The six inch thickness of cotton and asbestos give best results but the asbestos 4 inch appears to be one of the cheapest and also very effective. It is not subjected to mildew that would occur on cotton and also not effected by rot and odors so prevalent with planing shavings and sawdust. Apparently wet sawdust is a better insulator than dry sawdust, the results indicating quite an advantage in wetting this material. However, this is the only substance that showed such a phenomenon.

Other studies are to be continued next year with other materials such as felt, cork, celotex, infusorial earth, etc., to get further comparisons and it is hoped that more extensive investigation will result in fuller information on the efficiency of these wall fillers.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

A STUDY OF SOME NORTH CAROLINA WASTE PRODUCTS

By E. E. Randolph

For three hundred years North Carolina has been preëminently an agricultural state. Rich in natural resources it is not surprising that the state should for the time be prodigal of them. Unwise methods have destroyed our long leaf pine industry. Forest fires and ill-advised lumbering methods have bared our mountain sides. For a long time our farms were immune to blight, Hessian fly, and boll weevil, but lack of watchfulness has laid our fields open to these pests.

During the past twenty years the state has been transforming itself into a great center of industry. Several causes combine to promote industry in the state, among which are: 1, Abundance of raw material; 2, Adequate water power doing the work of over six million men; 3, An unexcelled transportation system; 4, Accessibility to markets; 5, Supply of skilled and common labor; 6, Climate suitable for all-year-round production; 7, Well distributed supplies of pure water. As a result of such advantages the industries of the state have grown until the value of the annual production nears the billion dollar mark. Such enormous production naturally drains the resources of the state. Consequently our minds are concerned with possible substitution of materials which are abundant, available, and practically useless at present. A few of these possibilities will be mentioned and their economic value suggested.

Three paper mills are in operation in the state. The two companies at Roanoke Rapids each produce daily about twenty-five tons of craft paper and wall and carton board. The Champion Fiber Company at Canton produces over one hundred and fifty tons of finished paper per day. The 1926 tonnage of this company of both raw material and of finished products was 826,000 tons, a daily average of 2,650 tons. The annual pay-roll of this company is $2,300,000. It is interesting to note that a goodly per cent of the paper for United States postal cards and stamps is made at this plant. Although the holdings of this company amounts to thousands of acres of forest land, the enormous tonnage of wood used taxes the natural production. Contrary to the destructive practice of many lumbering companies this company uses scientific forestry and lumbering methods. Young growth is not wantonly

destroyed. On the other hand three nurseries are maintained, producing more than one million trees annually for reforestation.

As our timber resources decline and the demand for paper and artificial silk increases necessity will compel us to look elsewhere for pulp. The Forest Products Laboratory has experimented on corn stalks and cotton stalks for paper pulp. It is evident that these sources of pulp material are not practicable whatever may be their properties. The cost of harvesting, baling, and shipping would be too great. Our minds turn then to materials of little present value, but which in the nature of the case are collected as by-products and which are in available form.

The 56 cotton oil mills of the state crush annually 325,000 tons of cotton seed. The valuable parts of the seed are the oil and the meal. The average composition of a ton of seed is oil 300 pounds, meal 1000 pounds, hulls 600 pounds, loss 100 pounds. The hulls are used only for a carrier of the meal to prevent its too great concentration in the cow's stomach and to dilute the meal to bring the protein content down to the legal values. They have no particular food value. In a sense then they are practically a waste product. Nearly 100,000 tons of hulls are collected at the mills as by-products. Very little preparation would be necessary to use them for cellulose conversion products.

This state is a leading producer of peanuts. Large quantities of peanut hulls are accumulated at the cleaning mills. They are not suitable for foodstuff. They are used as fuel for the engine, but they do not make a satisfactory fuel. They burn with too great flash and do not give a steady source of heat. Investigation has shown that the hulls of both cotton seed and of peanuts are largely cellulose and are capable of yielding cellulose conversion products: alcohol, furfural, paper pulp, guncotton, collodion, pyroxylin and hence rayon and varnish products. Peanut hulls and stalks are easily bleached and yield long fibers which mesh well and make a strong paper. Cotton seed hulls, however, are somewhat difficult to bleach and the fiber is short. But when the hulls are mixed with the fiber obtained from the second ginning at the oil mill a satisfactory craft paper can be made.

The Du Pont Company has shown at their Georgetown plant that saw dust can be distilled for turpentine, alcohol, acetone, acetic acid, or crude pyroligneous products. This state has always produced its own lumber. A number of large band saw mills are regularly in operation, yielding quantities of saw dust, slabs, refuse lumber, and tree tops. Much of the lumber has been sawed by small portable mills. Until recently the roads of our state were not generally good. It was

more convenient therefore to move the mill from forest to forest than to haul the logs over existing roads. The consequence is that all over the state are found small mountains of saw dust and refuse timber. The Forest Service of the state is now advocating community coöperative mills. With such a plan it would then be an economical and practical matter to distil at these centers the saw dust and cast off timber. The margin of profit does not justify at present transportation of saw dust from dozens of small mills to a central distilling plant.

The Spirittine Company at Wilmington is doing a prospering business by steam distillation of pine stumps and refuse pine timber. By this means the waste pine timber is utilized to make about a dozen valuable distillation products, such as wood turpentine, creosote, disinfectants, and solvents.

The 65 fertilizer plants of this state produced in 1926 560,000 tons of commercial fertilizers, nearly one-eighth of all the commercial fertilizer manufactured in the United States. The commercial value of this state product was over $26,000,000. Also over one million dollars worth of fish scrap was produced. Hence we are intensely interested in the question of fertilizers. But all of the phosphate rock and most of the ammonia ingredients and potash come from elsewhere. How valuable it would be to the state if at least some of these ingredients could be obtained from some of the waste products of the state. It has been found that the shale and low grade coal from the Deep River coal fields contain high percentages of ammonia and phosphates. These shales yield a high grade of petroleum. The gas and pitch furnish almost enough heat to distil the oil. The ammonia and phosphates will nearly cover the cost of the extra heat and the mining. The petroleum in this way will be almost clear profit.

It has become the practice in this state to issue bonds to build permanent roads, and the income from the roads is rapidly repaying the bonds. Yearly millions of dollars are spent for foreign cement. It would seem practicable that much of the cement used for roads and buildings should be made in the state. Vast deposits of cochina are found in the New Bern area with only a light overburden. This material contains 47 per cent lime. Clay also is available near by. Since this material is available and not in use it is a waste product and should be put to use.

An exhaustive study of the subject would reveal still other materials which may be potential sources of wealth, comfort, and convenience to the people. Although in many cases it may be possible to make prod-

ucts by synthetic and by conversion methods, it may not be feasible to make immediate use of them because of existing prices of the materials made from other sources. The very possibility of their employment acts as a stabilizer to prices. It is not unusual for commercial interests to capitalize on a diminishing supply. As an illustration, twenty-five years ago the world was practically dependent on Chile for its nitrates. Today it is about 30 per cent dependent. Of the 1,500,000 tons of inorganic nitrogen consumed in 1925 31 per cent was Chile nitrate, 24 per cent was by-products nitrate, and 45 per cent atmospheric nitrogen. For this reason Chile nitrate will not likely attain prohibitive prices. The fact that alcohol may be made synthetically will probably keep the price of industrial alcohol within reason.

It is always easier and more attractive to use the best and leave the other, but in this keen competitive age it is becoming more and more necessary that we "gather up the fragments that nothing be lost."

STATE COLLEGE,
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A PROPOSED NEW FORMULA FOR THE STRENGTH OF COLUMNS

By T. F. Hickerson

The function of columns used so extensively in bridges, buildings and other engineering structures is to safely resist compressive loads. The internal compressive stresses caused by the direct loads are quite determinate, but the additional stresses resulting from the possibility of incipient bending may reach the yield point of the material and produce a sudden collapse of the column.

This dangerous bending tendency, which is characteristic of slender columns, is of an indeterminate nature, since the actual final deflection resulting from bending is unknown.

If the column is perfectly straight, the material absolutely homogeneous, and the load is applied exactly along the central axis, then it may be said that the column will not bend at all under a load. But no such perfectly ideal conditions exist in practice. The column is likely to have a slight initial bend before the load is applied, there may be non-uniform initial stresses set up in the material due to riveting the parts together, the material may be non-homogeneous, and the load may be applied slightly off center.

The effect of initial crookedness, initial stresses, lack of homogeneity of the material, unintentional or accidental eccentricity, etc., may be accounted for by an assumed initial bend at the middle and eccentricity of loading at the end, which if applied to the perfect column will cause it to fail at the same load as the imperfect column of practice.

Let figure 1 represent a round or pivoted column subjected to a load P which is applied e inches off center at the end. The column also has a slight initial bend. Before loading, its axis (fig. 1b) is assumed to have the shape ACB; after loading, it will take the shape AOB.

Notation: Let

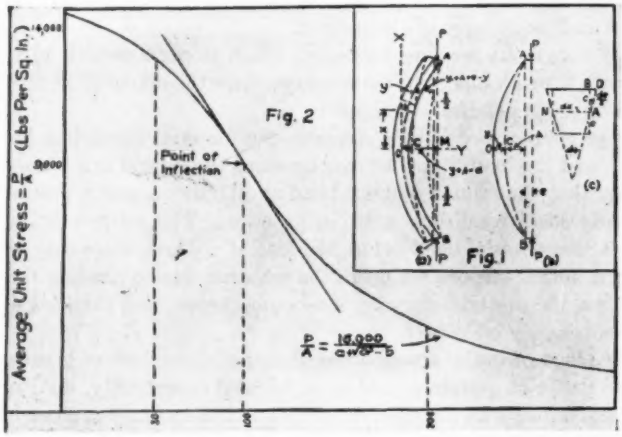
P = column load.

l = unsupported length.

r = radius of gyration about the axis of bending.

$\frac{l}{r}$ = slenderness ratio.

I = moment of inertia about the axis of bending.
A = cross section.
e = accidental end eccentricity of loading.
Δ = initial deflection of the mid-section due to the initial bent shape of column.
y_1 = additional deflection of the mid-section due to the load.
c = distance from neutral axis of cross section to outside fiber.
f = maximum unit stress at the concave side of column.
f_b = maximum unit fiber stress due to bending only.
$\frac{P}{A}$ = average unit stress.
M = bending moment.



Using rectangular axes, the origin will be assumed at O, the center of the bent column.

The ordinate of point A with reference to the OX-axis is the *same* relatively as the central deflection of the column.

Consider an elementary slice of the column of length ($= dx$). The strain of this small portion of the column through an angle $d\theta$ causes the end A to deflect (relatively) towards the right an amount equal to $\left(\frac{l}{2} - x\right)d\theta$.

Summing up these small deflections due to the successive strains of all the elementary parts from O to A gives the total deflection CO of the mid-section.

From figure 1c, which is an exaggerated view of an elementary portion of the column, we have,

$$d\delta = \frac{2BD}{AB} = \frac{f\,dx}{Ec} = \frac{Mc\,dx}{IEc} = \frac{M\,dx}{EI} \tag{1}$$

The bending moment at any section of the column is

$$M = P(y_1 + \Delta + e - y). \tag{2}$$

At the mid-section of the column, the moment is greatest.

Hence

$$M(\text{maximum}) = P(y_1 + \Delta + e) = f_b \frac{I}{c} \tag{3}$$

Substituting equation (2) in equation (1), we have,

$$d\theta = \frac{P(y_1 + \Delta + e - y)dx}{E\,I} \tag{4}$$

The elastic curve AOB (fig. 1b) is assumed to be a parabola. That is,

$$y = \frac{4(y_1 + \Delta)}{l^2} x^2.$$

Now the deflection of A relative to O due to bending is:

$$y_1 = \int_o^{l/2} \left(\frac{l}{2} - x\right) d\theta.$$

Substituting equation (4) for $d\theta$, we have,

$$y_1 = \frac{P}{EI} \int_o^{l/2} \left(\frac{l}{2} - x\right)(y_1 + \Delta + e - y)dx.$$

Integrating and reducing, we have,

$$y_1 = \frac{\frac{Pl^2}{EI}\left(\frac{5}{48}\Delta + \frac{e}{8}\right)}{1 - \frac{5}{48}\frac{Pl^2}{EI}} \tag{5}$$

Equation (5) shows that the coefficients of Δ and e differ in the ratio of about $\frac{1}{10}$ to $\frac{1}{8}$. Hence it is not correct to treat the initial deflection of the mid-section as if it were equivalent to an equal end eccentricity, as is done in deriving the well known secant formula.

If both Δ and e are zero, then $y_1 = 0$. But if y_1 is *not* zero, then $y_1 = \frac{0}{0}$ = any finite quantity. However y_1 must be very small, since x was assumed $= \frac{l}{2}$.

Since the denominator of equation (5) is zero (if y_1 is not zero), then

$$P = \frac{48}{5}\frac{EI}{l^2} = 9.6\frac{EI}{l^2},$$

which is practically the same as Euler's formula.

If the bent axis AOB had been assumed a *sine curve* instead of a parabola, then the factor 9.6 would be replaced by π^2 (or 9.87), thus agreeing exactly with Euler's formula. Hence we are justifiable in substituting $\frac{1}{9.87}$ for $\frac{5}{48}\left(=\frac{1}{9.6}\right)$ in the denominator of equation (5). Also, reasoning by analogy, the term 9.6 in the numerator of equation (5) should be changed to 9.87. This will be done in deriving equation (7) given later.

On account of both direct stress and bending resulting from column action, we have,

$$f = \frac{P}{A} + \frac{Mc}{I} = \frac{P}{A} + \frac{P(y_1 + \Delta + e)c}{A\,r^2} \tag{6}$$

Substituting the value of y_1 from equation (5) in equation (6), simplifying, reducing, solving the resulting quadratic and rationalizing the numerator, gives,

$$\frac{P}{A} = \frac{2f}{1 + (\Delta + e)\frac{c}{r^2} + \frac{1}{9.87\,E}f\left(\frac{l}{r}\right)^2 \pm \sqrt{\left[1 + (\Delta + e)\frac{c}{r^2} + \frac{1}{9.87\,E}f\left(\frac{l}{r}\right)^2\right]^2 - \frac{4f}{9.87\,E}\left(\frac{l}{r}\right)^2\left(1 - \frac{ec}{5r^2}\right)}} \tag{7}$$

Equation (7) gives the column formula in its most general as well as its most nearly rational form.

If $\frac{l}{r}$ approaches zero, then; using the plus sign,

$$\frac{P}{A} \doteq \frac{f}{1 + (\Delta + e)\frac{c}{r^2}},$$

Using the minus sign,

$$\frac{P}{A} \doteq \frac{f}{0} \doteq \infty.$$

If $(\Delta + e)$ approaches zero,

$$\frac{P}{A} \doteq \frac{2f}{1 + \frac{1}{9.87\,E} f\left(\frac{l}{r}\right)^2 \pm \sqrt{\left[1 - \frac{1}{9.87\,E} f\left(\frac{l}{r}\right)^2\right]^2}}$$

Using the plus sign,

$$\frac{P}{A} \doteq f,$$

Using the minus sign,

$$\frac{P}{A} \doteq \frac{9.87\,E}{\left(\frac{l}{r}\right)^2} \text{ (Euler's formula)}$$

Evidently the plus sign *only* should be adopted in applying formula (7). Let $\frac{ec}{r^2} = 0.1$, $\frac{\Delta c}{r^2} = 0.0015\,\frac{l}{r}$, $f = 36{,}000$ pounds per square inch. Dividing numerator and denominator of equation (7) by 2, and using a factor of safety $= 2\frac{1}{4}$, we have

$$\frac{P}{A} = \frac{16{,}000}{a + \sqrt{a^2 - b}}, \tag{8}$$

where $a = 0.55 + 0.00075\,\frac{l}{r} + 0.00006079\left(\frac{l}{r}\right)^2$, $b = 0.000119149\left(\frac{l}{r}\right)^2$.

On plotting equation (8), the curve is seen to be as represented in figure (2). A *point of inflection* occurs where $\frac{l}{r}$ is about 100. Therefore the curve is a cubic or higher powered parabola.

The curve will be assumed a cubic parabola of the form:

$$\frac{P}{A} = K + A\left(\frac{l}{r}\right) + B\left(\frac{l}{r}\right)^2 + C\left(\frac{l}{r}\right)^3 \tag{9}$$

From formula (8), we have the following data:
If

$$\frac{l}{r} = 0, \frac{P}{A} = 14{,}545.$$

$$\frac{l}{r} = 30, \frac{P}{A} = 13{,}768.$$

$$\frac{l}{r} = 100, \frac{P}{A} = 8{,}858.$$

$$\frac{l}{r} = 200, \frac{P}{A} = 2{,}975.$$

Substituting the above values in equation (9) gives four equations from which the four unknowns K, A, B, and C may be obtained by solving simultaneously, giving $K = 14{,}545$, $A = -5$, $B = -0.77$, $C = 0.0025$.

Substantially the same results are obtained if we let, for the sake of simplicity, $K = 14{,}500$, $B = -0.8$, $C = 0.0025$.

Then equation (9) takes the form:

$$\frac{P}{A} = 14{,}500 - \left(\frac{l}{r}\right)^2\left[0.8 - 0.0025\,\frac{l}{r}\right] \tag{10}$$

Equation (10) is therefore a simplified approximate formula which is in close agreement with the more complicated exact formula for all values of $\frac{l}{r}$ from 0 to 150. Practically all the steel columns used in practice come within this range.

Figure (3) shows that the curves representing equations (8) and (10) almost coincide.

Figure (4) gives 60 results (see dots) of Tetmajer's series of 104 tests on mild steel columns loaded to failure. For ultimate conditions, it is seen that the curve of equation (8) falls under these dots, thus allowing a further margin of safety. Euler's formula is seen to agree fairly closely with these tests when the slenderness ratio is larger than 120.

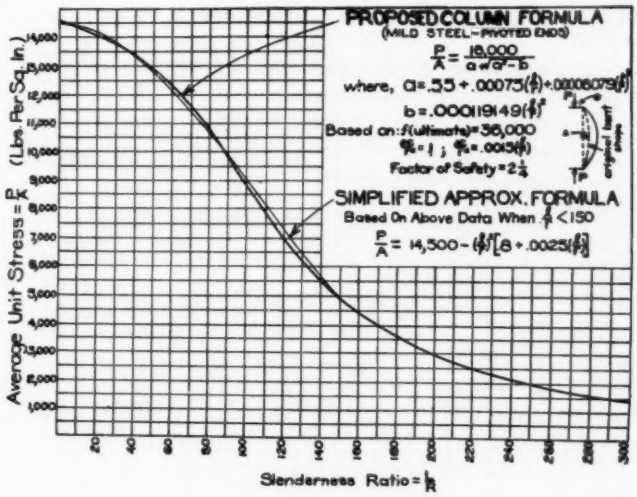

PROPOSED COLUMN FORMULA
(MILD STEEL - PIVOTED ENDS)
$\frac{P}{A} = \frac{18,000}{a+c\left(\frac{l}{r}\right)^2 - b}$
where, $a = .55 + .00075\left(\frac{l}{r}\right) + .00006079\left(\frac{l}{r}\right)^2$
$b = .000119149\left(\frac{l}{r}\right)^4$
Based on: f(ultimate) = 36,000
$\frac{P}{A} = 1$; $\frac{P}{A} = .005\left(\frac{l}{r}\right)$
Factor of Safety = $2\frac{1}{4}$
SIMPLIFIED APPROX. FORMULA
Based On Above Data When $\frac{l}{r} < 150$
$\frac{P}{A} = 14,500 - \left(\frac{l}{r}\right)^2\left[.8 + .0025\left(\frac{l}{r}\right)\right]$
Average Unit Stress = P/A (Lbs. Per Sq. In.)
Slenderness Ratio = $\frac{l}{r}$

Fig. 3

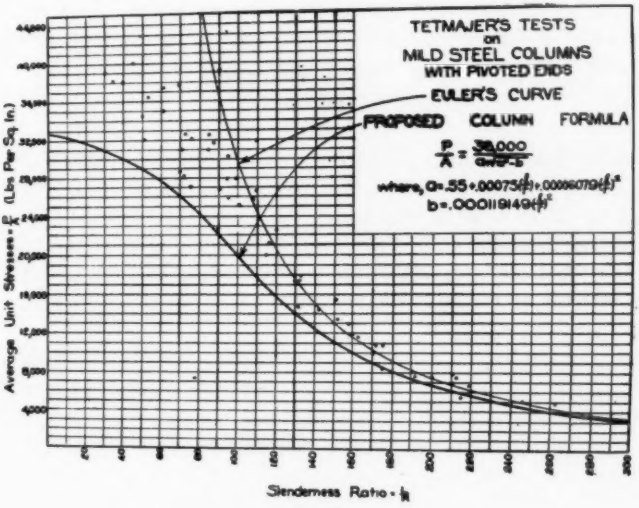

TETMAJER'S TESTS
on
MILD STEEL COLUMNS
WITH PIVOTED ENDS
EULER'S CURVE
PROPOSED COLUMN FORMULA
$\frac{P}{A} = \frac{36,000}{a+c\left(\frac{l}{r}\right)^2 - b}$
where, $a = .55 + .00075\left(\frac{l}{r}\right) + .00006079\left(\frac{l}{r}\right)^2$
$b = .000119149\left(\frac{l}{r}\right)^4$
Average Unit Stress = P/A (Lbs Per Sq In.)
Slenderness Ratio = $\frac{l}{r}$

Fig. 4

The curves of figure (5) show the proposed column formula as compared with:

(a) The conservative Philadelphia Rankine formula (curve 2).
(b) The A.R.E.A. formula (curve 3).
(c) The American Bridge Company formulas (curve 4).

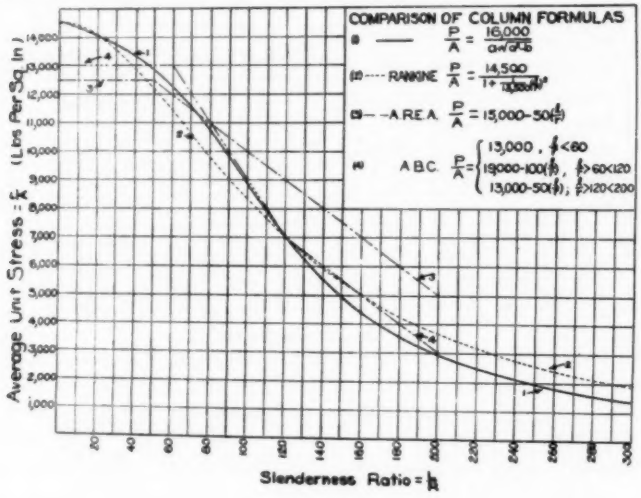


Fig. 5

The proposed formula allows for a small accidental end eccentricity and initial crookedness which increases with the column length. A factor of safety of $2\frac{1}{4}$ is also assumed. Since the columns of practice are restrained at the ends, there is an additional factor of safety due to the fact that the proposed formula is based upon round or pivoted ends offering no restraint whatsoever.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

LIFE HISTORY OF THE PLUM CURCULIO (CONOTRACHELUS NENUPHAR HERBST.)[1]

By C. H. Brannon

Plate 1

Introduction

The plum curculio (*Conotrachelus nenuphar* Herbst.) is the most destructive insect pest of the peach fruit. This insect has threatened to bankrupt the peach industry of Georgia and other states and is known as the "Two Million Dollar Bug" by Georgia peachgrowers because the damage to the crop in 1920 totaled more than that amount.

The plum curculio has not always threatened the peach crop in Georgia as it has in recent years, but due to the fact that many more trees have been set out recently, the curculio has had more fruit and a larger area over which to breed. Careless spraying and negligence in other control measures has enabled the curculio to increase in numbers each year, until this insect threatened the peach industry of Georgia.

Systematic spraying and the use of other intelligent control measures, in 1921, paved the way for the marketing of one of the biggest, cleanest, most successful peach crops that has ever been shipped from the Georgia peach belt. Georgia had two successive crop failures previous to 1921, as a result of the ravages of the plum curculio.

Curculio Relation to Brown Rot

Pathologists state that brown rot gains easy entrance through the curculio punctures in the fruit. Therefore, the curculio is not only responsible for direct injury which results in "wormy" peaches, but it is also in a large measure responsible for rot infection.

[1] This work was done under the supervision of Mr. O. I. Snapp while the writer was employed by the U. S. Dept. of Agriculture at Fort Valley, Ga., from April 1, 1921 to October 1, 1921.

LIFE HISTORY AND HABITS

The plum curculio (*Conotrachelus nenuphar* Herbst.) belongs to the family *Curculionidae* sub-order *Rhynchophora* and order *Coleoptera*. This insect deposits eggs in the fruit of the peach, the larvae developing in the fruit and pupating in the soil.

Considerable life-history work had been done on the curculio (1900–1910),[2] but there was much work to be done. Several new facts concerning the life history of the curculio were established and proved at the Fort Valley insectary in 1921.

The most important objective to be gained was to establish conclusively, affirmatively or negatively, the popular belief among entomologists, that there are two generations of the curculio each year in Georgia instead of only one. It was *established affirmatively beyond any doubt* that there are *two* generations of the curculio. This fact was established by securing eggs from first generation beetles. These eggs developed into second generation adults.

It is an established fact that the plum curculio lays most of its eggs the last of March and the first of April. The curculio is exceedingly active at this time, but during the stone hardening period of the peach, the curculio damage decreases very noticeably; but after this period or during the ripening period of the fruit, the insect resumes feeding and oviposition with great intensity. This phenomenon was formerly explained in this way: It was believed that the curculio refrained from ovipositing in the fruit during the stone hardening period through instinct, as the fruit at this stage is very detrimental to the development of the larvae. The hardening tissues of the fruit cause enormous mortality. After this period the curculio resumes oviposition as before. This theory has now been proved to be incorrect.

We know that the very noticeable increase of "wormy" fruit during the ripening period is due to oviposition of beetles which are the progeny of hibernated curculios. These first generation beetles oviposit freely in the ripening fruit. The fact that the progeny of the hibernated weevils emerged in time to attack the fruit, was always accepted, but previous investigators had failed to secure eggs from the first new generation (or the progeny of the hibernated beetles). Hence, entomologists who did previous work on the plum curculio stated that the first new generation did not oviposit but only fed until cool weather, when they went into hibernation, resulting in only one generation a

[2] U. S. Bureau of Entomology, Bull. 103.

year. Previous investigators stated that this generation caused the serious damage just after the peaches were set in the spring.

The beetles that survive the winter are the progeny of first generation curculio and *not* the progeny of hibernated curculio. Heavy infestation at the time the fruit ripens is due to the ravages of the first new generation. The establishment of a *second generation* has already changed control measures so far as discing the soil is concerned, and will in all probability, be the basis for other changes in the future. The fact that a second generation has been established is not only of commercial value but is also an important biological discovery.

We were unable to secure eggs from the adults of the second generation in peaches, apples, or *Crataegus*. Plums were all gone at this time.

The plum curculio prefers plums, for oviposition to any other fruit, therefore plums were used in these oviposition studies while available. Peaches were used when plums could not be obtained.

Egg counts of twenty-five female curculio, taken *in coitu*, were made daily for six months; but due to a very destructive fungous disease, the oviposition results are incomplete. (This fungus was very noticeable among the beetles in the longevity jars also.) Jelly jars filled one-third full with moist sand, were used in oviposition isolation. The sand was kept moist. The highest number of eggs secured from a single female curculio was 218, which extended over a period of five months. The mate to this beetle died in a week after isolation with the female, but this seemed to have no effect on oviposition. The curculio copulates intermittently throughout the season, but just what affect this, or copulation only when taken *in coitu*, has upon oviposition was not determined.

A complete longevity record, of beetles collected from jarring frames, was conducted. One hundred adults collected by jarring were placed in a battery jar with moist sand in the bottom. The jars had muslin cloth tops. At the end of the season there were about 30 longevity jars on hand. At the first of the season counts were made of the beetles in each jar three times a week. The last of the season these counts were made only once a week.

From 100 hibernated beetles that were collected from the jarring frames on March 21, 1921, there were 15 alive on October 1, 1921. Twelve of these beetles went back into hibernation, proving that the beetles live longer than a year. These beetles died in hibernation.

In insectary environment we got 2–10% mortality each week, in the longevity jars.

Soil was placed in glass bottom boxes. Larvae that emerged from infested fruit were placed on the soil. Most of the larvae made cells next to the glass. Data were taken on the length of time the insect required to change from larva to pupa and from pupa to adult. It was not determined how long the adult remained in the cell prior to emergence due to the fact that upon transforming from pupa to adult the adult scratched the earth over the bottom of the cell and could not be observed. The cells were marked with a blue pencil and numbered as the larvae pupated. When the pupae changed to adults T was marked by the cell. The time required by the curculio to pass through the different stages varies, of course, with the temperature, but on the average the larvae remain in the cells 10–14 days before pupating.

MISCELLANEOUS NOTES

The only way the writer could differentiate between the sexes of the adults of the plum curculio was by a minute examination of the beak under a binocular microscope. The beak of the male is less symmetrical, more indented, and straighter than that of the female.

The curculio stridulates by working the end of the abdomen up and down violently. They seem to stridulate only when excited or disturbed.

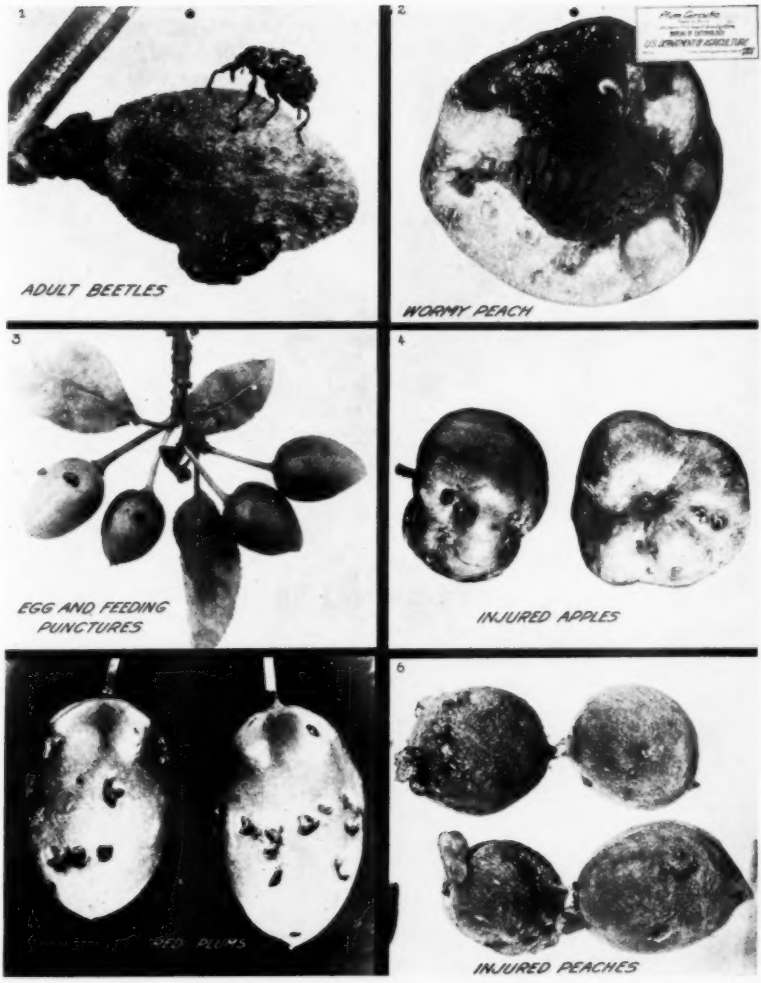
A great number of parasites were collected by placing larvae in boxes and covering the boxes with muslin. These covers were removed in a "monkey cage" and the parasites easily collected. The parasites were abundant in 1921 due to dry weather. Egg and larvae parasites were collected in large numbers.

To emphasize why so many larvae and pupae reach the adult stage regardless of adverse conditions, a larva and a pupa were removed from their cells in the soil and placed in a tumbler of water (they were completely immersed the whole time) for 24 hours. Both recovered after being taken out. The larva recovered in five minutes and the pupa recovered in twenty minutes.

Larvae that were taken from cells in the soil pupated on top of the soil and in glass vials. Pupae taken from the soil transformed to adults inside of vials.

To give some idea of the curculio infestation in Georgia in 1921, 2½ bushels of small "drops" which were picked up commercially were brought into the insectary on April 8, and from these drops over 13,000 curculio larvae emerged.

PLATE 1



PLUM CURCULIO (CONOTRACHELUS NENUPHAR HERBST.)

Courtesy of U. S. Dept. Agriculture

THE
JOHN CRERAR
LIBRARY

SUMMARY

There are two generations of the plum curculio in Georgia.

Curculios which were collected by jarring early in the spring were placed in oviposition jars. These hibernated curculios produced a first generation, and the first generation adults oviposited producing a second generation.

The life history of the curculio in North Carolina is essentially the same as the curculio in Georgia, therefore, the data included in this paper will apply in general to conditions in North Carolina.

CAVE FAUNA WITH ESPECIAL REFERENCE TO ECOLOGICAL FACTORS

By J. D. Ives

Numerous caves have been explored but only five are presented. The caves vary in size from a few hundred feet to several miles in extent. One cave is in granite, the others are in limestone. Ecology classes have been utilized in the cave study. The identifications of the animals obtained were made through the kindness of the U. S. National Museum at Washington, D. C.

Problems.

(A) Immediate

(1) To determine the cave fauna found in different caves, and in different parts of the same cave.

(2) To ascertain their present ecological factors.

(B) In view.

The possible origin of new forms.

A new species of fly, *Rymosia*, n.sp., a new species of centipede, *Nampabius major*, and a new genus and species of spider, *Ivesia tennesseensis*, have already been discovered.

Bat Cave

Bat Cave is located near Chimney Rock and Bat Cave, N. C. It is in granite rock and was evidently formed by the movement or arrangement of the rocks and not directly by erosion. The entrance, which façes N–E., has a width of 29 ft., and a height of about 25 ft. After a steep descent for 25 ft. the main part of the cave, which is over 100 ft. in extent, runs sharply in an east-west direction. Thus the light from the entrance is shut off. The average height of the cave is 40 or 50 ft. No standing or running water was found in the cave.

The ecological conditions, save light, are nearly those of the surrounding regions and the animals are apparently what might be found on the outside of the cave in the shade, such as centipedes, millipeds, stilt bugs, "sow bugs," Thysanurans, earthworms, snails, etc. Their being in the cave was apparently accidental, which could not be said altogether of the other caves.

THREE SPRINGS CAVE

Three Springs is located five miles from Russellville and ten miles from Morristown, Tenn.

The entrance to the cave is in a cliff only a few yards from Holston River. The entrance faces north and is rather small though the cave gets quite sizable within.

The fauna and ecological conditions are considered in known distances from the entrance. The measurements were made with a steel tape and marks were made on the walls of the cave at 100-foot distances.

25 feet.

Temperature and humidity variable. Region of twilight.

Fauna.

The salamander, *Eurycea lucifuga.*
The moth, *Scoliopteryx libatrix.*
The slug, *Limax maximus.*
Thysanurans.
Camel crickets, *Ceuthophilus ensifer* Pack. (quite numerous).
Spiders.

50 feet.

Temperature and humidity variable. The light very faint.

Fauna.

Camel crickets, *Ceuthophilus ensifer* Pack.
The fly, *Rymosia* (new species). The flies are about the size of mosquitoes and they were found resting with their bodies nearly at right angles to the roof of the cave.
The fly, *Amoebaleria defessa* O. S. This fly is only a little less in size than the ordinary house fly. It was found resting with its body parallel to the roof of the cave.
A Snail.
The Moth, *Scoliopteryx libatrix.*
Thysanurans.

75 feet.

Temperature and moisture still somewhat variable.

Fauna.

Camel crickets, *Ceuthophilus ensifer* Pack.
The moth, *Scoliopteryx libatrix.*
A Milliped.
Spiders.
Thysanurans.

100 feet.

Temperature and moisture but slightly variable. Total darkness due to a bend in the cave.

Fauna.

Camel crickets, *Ceuthophilus ensifer* Pack. (numerous).
A Milliped.

The Salamander, *Eurycea lucifuga*.
The fly, *Rymosia* n. sp.
A Bat (solitary).
Spiders.

150 feet.
Fauna
Camel crickets, *Ceuthophilus ensifer* Pack.
Bats.
Spider.
Flies, *Amoebaleria defessa* O. S.

200 feet.
Fauna
Camel crickets, *Ceuthophilus ensifer* Pack.
Flies, *Amoebaleria defessa* O. S.

300 feet.
Fauna, same as at 200 feet.

400 feet.
Fauna.
A small brown bat.
The milliped, *Cambala annulata*.

600 feet.
Fauna
Spiders
Millipeds.

800 feet. (innermost recess of cave).
The temperature does not vary more than one or two degrees, for example the temperature was 60°F. on Jan. 17, 1927, and 58°F. on April 13, 1927. The humidity also is practically constant being about 80 per cent. The instrument used was Lambrecht's Hygrometer, No. 3643 Palo Company, New York City. The air is pure, since the carbon dioxide content of the air is less than 0.7 parts of carbon dioxide to 1000 parts of air. Absolute darkness prevails. The pressure is 28.9 inches, and it is 25 feet below the entrance of the cave. There are no perceptible air currents.
Fauna.
The salamander, *Gyrinophylus danielsi*.
The milliped, *Cambala annulata*.
The rove beetle, *Echochara lucifuga*, (obtained underneath meat bait which was placed in the cave).
Spiders were quite numerous on the sides of the chamber, but as yet they have not been determined.
Flies, *Sciara* sp., also were caught by means of a white cloth to prevent injury.

From the above it may be noted that 100 feet was the farthest point penetrated by the salamander, *Eurycea lucifuga*, while *Grynophilus danielsi* was the only salamander found at 800 feet. The moth, *Scoliopetryx libatrix*, penetrated the cave for only 75 feet, while the camel cricket,

Ceuthophilus ensifer Pack. was found in the cave at 300 feet. The rove beetle, *Echochara lucifuga* was found only in the innermost parts of the cave. The kinds of flies collected at 800 feet were also different from those near the entrance. The fly, *Sciara* sp., was collected only at 800 feet, while the fly, *Rymosia* n. sp., was collected only from 50–100 feet from the entrance, and the fly, *Amoebaleria defessa*, was collected 50–200 feet from the entrance.

INDIAN CAVE

Indian cave is located about five miles from New Market and ten from Jefferson City, Tenn.

The cave is somewhat over a mile in extent and a quite sizable stream flows through it. The entrance is at the base of a cliff which faces east on the Holston River.

250 feet.

The temperature and humidity are somewhat variable. Air currents are in evidence at certain times. It is in the region of twilight and if sunlight ever penetrates that far it is only possible for a very short time.

Fauna.

Bats, *Myotis grisescens*. Hundreds and perhaps thousands are attached to the ceiling at certain times.

The milliped, *Cambala annulata*, is very numerous, especially on fresh bat castings.

Several kinds of spiders inhabit the region which have not as yet been fully determined.

The ground beetle, *Platynus reflexus*, is now and then found.

A pseudoscorpion, *Chelifer sp.* is very abundant under stones.

The rove beetle, *Philonthus* sp. is extremely abundant especially on fresh bat castings.

A rove beetle belonging to the genus *Quedius* has also been found.

The small fly, *Desmometopia latipes* Mg., and a larger fly, *Fannia scalaria* Fab., were collected by the use of a strong flash light held underneath the bottom of a bottle which was held over a mound of bat castings.

1700 feet. Absolute darkness prevails at this distance. The temperature is 58°F. and is practically constant. The relative humidity is above 80 per cent. There are no perceptible air currents. The pH of the water of the stream was found to vary from 6.9 to 7.4. The oxygen content is 6.63 cc. per liter at 0 degrees C. and 760 mm. pressure. The Winkler method, as modified by Birge and Juday was the method used in determining the oxygen content of the water.

Fauna

The Spider, *Ivesia tennesseensis*, which is a new genus as well as a new species. The spider was named by Alexander Petrunkevitch. A description of the spider, written by Alexander Petrunkevitch, may be

found in "Annals of the Entomological Society of America" 18: 320. 1925.

The rove beetle, *Echochara lucifuga*. (quite abundant at times under meat bait).

The milliped, *Cambala annulata*.

The small stone fly, *Capnia*. (Only one specimen has been found during the three years of study of this cave).

The small fly, *Leptocera* sp., found in or around the bat excrement.

The salamander, *Gyrinophilus porphyriticus*.

The centipede, *Nampabius major*, which is a new species. It was named by Dr. Chamberlin of the Museum of Comparative Zoology at Cambridge, Mass. Thanks are due to J. M. Aldrich of the U. S. National Museum at Washington, D. C., for the proper distribution of specimens, since many were sent directly to him.

The crayfish, *Cambarus bartonii* var. *tenebrosus*. Determined by Dr. Waldo L. Schmitt. The crayfish was caught in the stream by placing meat bait near shore.

The small fungus gnat, *Sciara* sp., was determined by J. M. Aldrich. The delicate gnat was caught by placing a bottle of killing and preserving fluid over it after it had alighted on some white cheese cloth placed on sticks near the bat mound which was several feet high.

Bats were also abundant at certain times at this place.

5300 feet. The temperature and humidity are practically the same as at 1700 feet. Absolute darkness prevails. There are no perceptible air currents. The oxygen content of the nearby stream is 7.02 cc. per liter at 0 degrees C. and 760 mm. pressure. The pH of the water is 7.2.

Fauna.

Collected on or near bat castings the milliped, *Cambala annulata*, which sometimes is very abundant here.

The spider, *Ivesia tennesseensis*, is fairly abundant but not quite as abundant as at 1700 feet.

Gyrinophilus porphyriticus, a salamander determined by Doris M. Cochran. This salamander is also found at 1700 feet, but not at 250 feet.

The small fungus gnat, *Sciara* sp.

Bats are at times abundant.

Cambarus bartonii var. *tenebrosus* and *Caecidotea richardsonae* were collected from the nearby stream. The isopod, *Caecidotea richardsonae* (determined by J. O. Maloney), was found under stones and was quite abundant in places.

Thysanurans which were perfectly white.

From the above it may be noted that several kinds of spiders, the ground beetle, *Platyneus reflexus*, the pseudoscorpion, *Chelifer* sp., the rove beetle, *Philonthus* sp. and one belonging to the genus *Quedius*, and the two flies, *Desmometopia latipes* Mg. and *Fannia scalaria* Fab. did not penetrate the cave to 1700 feet.

The bats and the milliped, *Cambala annulata*, were at times abundant at 250 feet, 1700 feet and 5300 feet.

No white Thysanurans were found at 1700 feet though they have been found at 3360 feet and at 5300 feet. As far as discovered they prefer the inner parts of the cave.

The isopod, *Caecidotea richardsonae*, also was found only in the stream towards the end of the cave.

The salamander, *Gyrinophilus porphyriticus*, was not found near the entrance though another salamander, *Eurycea lucifuga*, was found there.

NICK-A-JACK CAVE

Nick-A-Jack Cave is located not far from Shellmound, Tenn. The Cave goes under the Tenn., Ga., and Ala. state lines.

The entrance of the cave is 150 feet wide and quite high. Nick-A-Jack cave is a large historic cave. The inner parts can be penetrated only by boats on which one must go a good part of the distance. A good description of the cave was given by "The Chattanooga Times" of November 28, 1926.

200 feet. Region of twilight with a variable temperature and humidity.

Fauna.

Large camel crickets, *Hadenoecus subterraneus* Scudd (determined by A. N. Caudell). These crickets were also found at 650 ft.

Sow bugs were taken from the roof of the cave near the walls of the cave.

The mosquito, *Anopheles quadrimaculatum* Say (determined by J. M. Aldrich), was quite abundant.

The fly, *Mycodrosophila dimidiata* Lw.

The fly, *Drosophila* sp.

The spider, *Theridium tepidariorum* Koch.

A small moth was also found.

2 or 3 miles.

Absolute darkness prevails. The temperature is 57°F.

Fauna.

The bat, *Pipistrellus subflavus subflavus* (determined by G. S. Miller, Jr.)

A few white Thysanurans were seen. In this cave as in the other caves the white Thysanurans are found only in the deep interior of the cave.

MAMMOTH CAVE

Mammoth Cave is located about ten miles from Cave City, Ky., and is one of the world's greatest and best known caves.

Entrance floor.

Temperature 50°F. (March 26, 1927). Relative humidity 58 per cent. The

temperature and humidity are variable at this point. Pressure 29.5 inches. Only slightly dimmed daylight.

Fauna.

Found under liverworts and mosses, stones, etc., small whitish spiders.

Spiders that were small but somewhat darker in color.

Rove beetles, *Atheta* sp.

Earthworms.

End of "little bat avenue."

Absolute darkness. Water was dripping from the roof of the cave at one side of the avenue.

Fauna. A few bats were found and the camel cricket, *Hadenoecus subterraneus*, was collected in crevasses near where the water was dripping.

Richardson's Spring.

Temperature 55°F. Relative humidity 80 per cent. Pressure 29.6 inches. Depth below floor of entrance 100 feet. Carbon dioxide of the air less than 0.7 parts to 1000 parts of air. Oxygen content of the spring water 7.93 cc. of oxygen per liter at 0 degrees C. and 760 mm. of pressure.

Fauna.

An Isopod, *Caecidotea richardsonae*, was found in the spring. It was perfectly white in color and was eyeless. It was crawling on the bottom of the spring where the water was moving but little.

Near the spring a spider was seen, also a milliped. A camel cricket, *Hadenoecus subterraneus*, was observed and collected.

"Echo River."

Chironomus sp. was collected from around the light in the boat on Echo River.

From the above it may be noted that the camel cricket, *Hadenoecus subterraneus*, penetrates Mammoth Cave a considerable distance, though it was observed only a few hundred feet in Nick-A-Jack Cave. The isopod, *Caecidotea richardsonae*, was found only at Richardson's Spring which is a considerable distance from the entrance. *Caecidotea richardsonae* likewise was found only in the inner parts of Indian Cave. In which case it was found in most abundance under stones in a slowly flowing part of the stream though a few were taken from beneath stones from comparatively swift parts of the stream.

CARSON-NEWMAN COLLEGE,
JEFFERSON CITY, TENN.

BLIGHT OF ASPARAGUS FERN

By FREDERICK A. WOLF[1]

PLATES 2 AND 3

INTRODUCTION

The asparagus fern, *Asparagus plumosus*, which is widely used in the preparation of floral decorations, is a crop of considerable importance in Florida. It is commonly grown in "slat houses" or ferneries which afford a partial shade and also a protection against inclement weather (pl. 2). The crop is harvested by cutting the branches when they have reached maturity, after which they are tied in bunches of suitable size, packed in boxes and marketed.

The writer's attention was directed, during the summer of 1925, to a disease of this crop to which growers inappropriately apply the name "rust." The trouble may better be designated "blight" since it manifests itself by the death and shedding of the so-called leaves which in actuality are branchlets that have come to function as leaves.

It appears upon inquiry from growers that this blight has existed for years and is practically co-extensive with *Asparagus plumosus* throughout the state. It may be found at any season but appears to spread most rapidly throughout the cooler portions of the year with little if any spread throughout the summer.

No reports of investigations of this disease appear to have been published, as determined by an examination of available literature. The present study which deals mainly with the nature and cause of this blight disease is therefore presented at this time as a basis for future investigation.

APPEARANCE

Both branchlets and stems are subject to infection. Blight is first evident as a drying and premature shedding of branchlets. It is usually most noticeable on the slender graceful branches of the kind which are to be marketed. In the case of severe infection the disease

[1] Formerly Pathologist, Fruit Disease Investigations, U. S. Dept. Agriculture.

INOCULATIONS

Proof of the pathogenicity of the blight fungus was secured by inoculation experiments conducted as follows. Young plants which had been grown for use in such tests and which were free from blight were inoculated by dipping the tips of the branches in a suspension of conidia from pure culture. Other plants in the same bed which were not inoculated served as controls. All of the plants in the test were covered for 24 hours with bell jars in order to maintain a high relative humidity. Five to seven days after inoculation the first evidence of infection was apparent as indicated by dead brown areas on the branchlets of inoculated plants. Within two weeks the branchlets had begun to shed in the manner characteristic of blight, whereas uninoculated plants remained normal in each of several trials.

CONTROL

No extensive attempts have been made by growers to control this disease partly because they have regarded it as due to improper fertilization or to unfavorable weather and partly because the application of sprays has not come into general use as a practice in fern culture. It might appear that the removal and destruction of the tops would be effective as a sanitary measure. Such a procedure is not practicable, however, since it cannot be made with sufficient thoroughness. Attention was therefore turned to the use of fungicides. It was apparent from the preliminary trials that Bordeaux mixture in the ordinary concentrations could not be employed because of the objectionable appearance of the dried film of spray on the branches. After several trials with various dilutions it was found that no appreciable coating of spray is formed when the Bordeaux is made in the proportions of one pound of copper sulphate, one pound of lime and 80 gallons of water. Material of this concentration has been employed with satisfactory control of blight throughout two seasons in a five-acre fernery. The spray was applied by preparing the concentrated solutions of lime and of copper sulphate and permitting them to be mixed and diluted as they flowed under pressure through the irrigation system and sprinklers. The interval between applications has varied from two to three weeks, dependent upon the rainfall and the rate of growth of the ferns.

SUMMARY

A blight of *Asparagus plumosus* which is widely prevalent on this crop in Florida is characterized by a drying and shedding of the branchlets.

This disease is caused by a fungus whose pycnidial stage has been identified as *Ascochytula asparagina* Petrak. An ascomycete morphologically identical with *Didymosphaeria brunneola* Niessl occurs on decaying stems and forms in culture a pycnidial stage indistinguishable from *Ascochytula asparagina*.

Pathogenicity has been proved by inoculations with pure cultures.

Frequent applications of dilute Bordeaux mixture give satisfactory control.

EXPLANATION OF PLATE 3

Figs. 1–6 drawn to scale shown beneath fig. 6; figs. 7–8, diagrammatic

Fig. 1. Surface view of fruit bodies of the conidial stage, *Ascochytula asparagina*.
Fig. 2. Conidia.
Fig. 3. Stages in germination of conidia.
Fig. 4. Single ascus from a crushed perithecium of *Didymosphaeria brunneola*.
Fig. 5. Variation in size and shape of ascospores.
Fig. 6. Germination of ascospores.
Fig. 7. Diagram of stem of *Asparagus plumosus* showing distribution of perithecia.
Fig. 8. Diagram showing protrusion of papillate perithecia from cortex.

PLATE 2

ASPARAGUS PLUMOSUS GROWING IN A FERNERY

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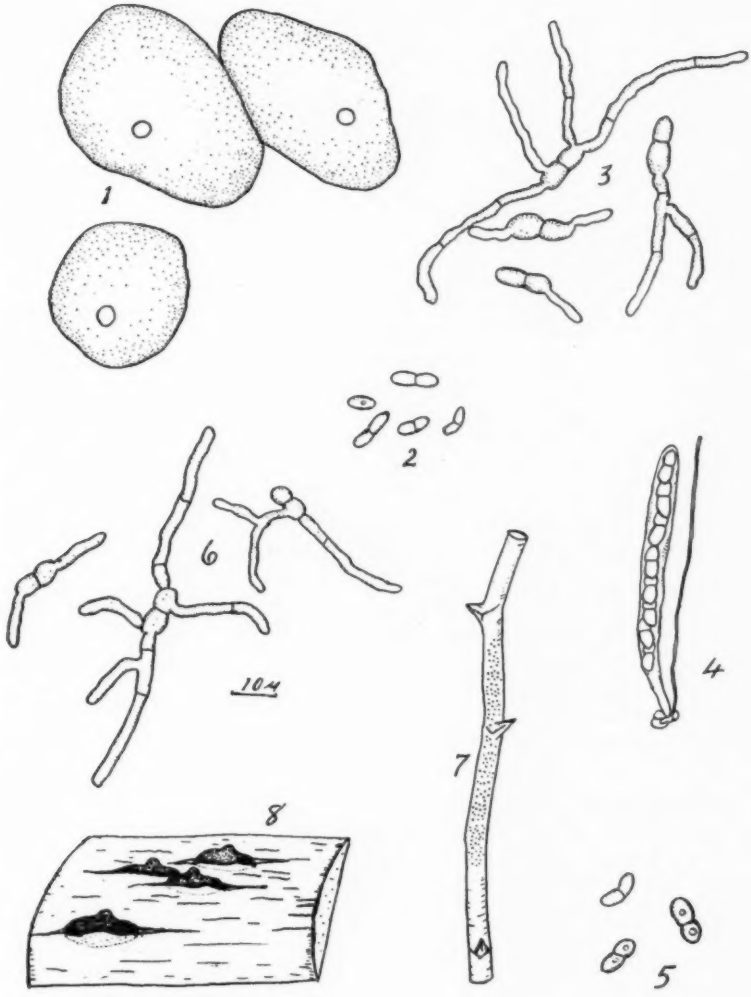
PLATE 3



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THE MORPHOLOGY AND SYSTEMATIC POSITION OF THE FUNGUS, MICROSTROMA JUGLANDIS (BERENG.) SACC.

By Frederick A. Wolf

Plate 4

The genus *Microstroma* is of especial interest to mycologists since some regard it as one of the Basidiomycetes and others as one of the Fungi Imperfecti. A detailed study of one of the species, *M. juglandis*, as it occurs on hickory, was therefore undertaken with the view of ascertaining its systematic position as shown by the structure of the fungus. When these studies were practically completed my attention was directed to a report of investigations on the same genus by Maire (1). The results of Maire's studies, because of the place of their publication, have remained rather inaccessible and are known to relatively few students of fungi. It is deemed advisable, for these reasons, to publish the present findings which confirm in all essentials the results set forth by Maire.

Microstroma juglandis is widely prevalent both in Europe and America on hickory and walnut. It is most abundant in spring as the leaves are approaching their mature size and is characterized by the presence of a white, powdery coating on the lower leaf surface. Large angular lesions, which are at first pale green and later become brown and dry, are formed as a result of the attacks by this parasite.

The material for this study consisted primarily of lesions on hickory leaves in various stages of maturity. This was supplemented by collections of a variety of the same fungus, *M. juglandis* var. *robustum*[1] on pecan catkins. The material was fixed, embedded in paraffin, sectioned to a thickness of 4–5μ, and stained with Haidenhain's iron-alum haematoxylin.

Sections of diseased leaves show that the fruit bodies simulate, in outline and arrangement of elements, sheaves of grain. Each consists

[1] The fungus on pecans was supplied through the kindness of Dr. B. B. Higgins, Experiment, Georgia.

of dense aggregates of hyphae whose basal portion occupies the substomatal cavity. The hyphae tend to be arranged parallel to each other but converge at the orifice of the stoma where they appear to be compressed, as with an encircling band, and then spread out again above the host tissues to become a fascicle of conidiophores (fig. 1). Each conidiophore is a clavate cell (figs. 3 and 5) which bears at its summit a crown of two to six conidia. These conidia are 6–8 x 4.5μ, oblong ellipsoidal in outline, and are borne on short sterigmata. The hilum is basal whereas the mode of attachment of basidiospores is extrose (fig. 5).

The mycelium is composed of hyphae which are very small in diameter and for this reason the hyphae can be traced with difficulty throughout the palisade parenchyma and mesophyll. It is entirely intercellular and can be seen best in the tissues near the bases of the conidial stromata. The cells of invaded tissues preserve their normal shape and appear to lose gradually their chlorophyll and other protoplasmic content.

The cells of the intercellular mycelium and of the hyphae which compose the mature stromata are uninucleate (fig. 6). At an early stage in the differentiation of conidiophores they too are uninucleate. However as they increase in size and in density of protoplasts, preparatory to emergence from the stomates, they become multinucleate. A single nucleus passes into each conidium as it is formed at the tip of the sterigma (figs. 5–6). After conidial formation has been completed two or three nuclei remain within the mature conidiophore. The nuclei no doubt increase in number and pass into the next crop of conidia after the first ones are dislodged. Observations indicate that successive crops of conidia are formed from the same conidiophore.

As has been indicated, well developed hyphae occur within the leaf tissues. When, however, the conidia are germinated on agar there is no evidence of hyphal formation. Instead the conidia give rise by budding to oval or elliptical bodies. This process continues until small, circular, grayish white colonies are developed. This corresponds with the observations by Higgins (2) on the same fungus and on the one from pecans. Furthermore these two fungi are alike morphologically except in size of conidiophores and conidia.

The fungus under consideration was first described in 1847 by Berenger (3) as *Fusidium juglandis* but was transferred by Niessl (4) in 1861 to the genus *Microstroma*. He regarded it as one of the Hyphomycetes of the Mucedinaceae—Micronemeae in which group the well

known genus *Oospora* belongs. This classification was followed by Lindau (Rabenh. Krypt. Flora 2nd ed. Pilze **8**: p. 17) and by Saccardo (Syll. Fung. **4**: p. 9, and Fungi Italici, no. 864). However Schroeter in 1888 (Pilze Schlesiens **1**: p. 414) because of the similarity of the conidiophores of *Microstroma* to the basidia of *Exobasidium* classified it with *Exobasidium* among the Exobasidiales. This classification was accepted by Hennings (Engler and Prantl, Natürl. Pflanzenfamil. 1.1[xx]: p. 105). Patouillard (Essai taxonomique, Hymenomycetes, p. 36) placed the same interpretation upon the structure of the conidiophores but regarded *Microstroma* as a subgenus of *Exobasidium*.

An interpretation of the present findings clearly indicates that *Microstroma juglandis* is not a Basidiomycete for the following reasons: (1) The polynuclear condition shows that the conidiophores are not basidia; (2) the conidia because of their shape and their manner of insertion on the sterigmata are not basidiospores; (3) conjugate nuclei which occur in many basidiomycetes are lacking in *Microstroma*. The plant must therefore be regarded as one of the imperfect fungi but here also there is reason for difference of opinion as to its proper position. The possession of a well developed mycelium, and of distinct conidiophores, except in culture, would appear to exclude the fungus from the Mucedinaceae—Micronemeae. Maire (1) has suggested that it rightly belongs among the Melanconiales near such genera as *Colletotrichum* and *Cylindrosporium*. The present writer is inclined to accord with this view.

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(3) BERENGER, A. Il Seccome de Gelso, coll esposizione di una nuova teoria dell Entofitensi, No. 4, p. 27. Padova, 1847. (Vide p. 7, fig. 1.)

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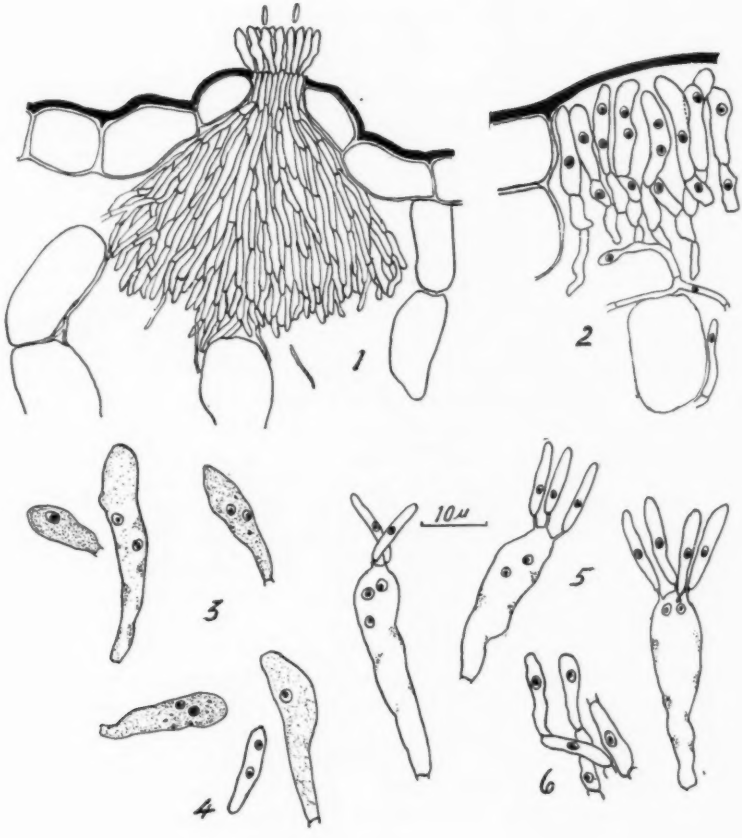
EXPLANATION OF PLATE 4

Fig. 1. Vertical section of fruit body of *Microstroma juglandis* on hickory leaf.
Fig. 2. Stroma in section showing young conidiophores before emergence. They have one to two nuclei. The cells of the stroma and of the intercellular mycelium are uninucleate.
Fig. 3. Conidiophores of the fungus from hickory showing variation in size. They possess one or two nuclei.
Fig. 4. Conidium of the hickory fungus which has increased in volume and become binucleate preparatory to budding.
Fig. 6. Conidia and conidiophores of *M. juglandis* var. robustum.
Fig. 5. Uninucleate cells from stroma of pecan fungus.
Figs. 2–6 are drawn to the same scale.

PLATE 4



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A VARIETY OF COLLYBIA DRYOPHILA PARASITIC ON DEWBERRY[1]

By R. F. Poole

Plates 5–7

A root rot disease of the Lucretia dewberry, *Rubus* sp., has been causing heavy losses in the commercial plantings in the sand hill soils in the vicinity of Cameron for the past few years. The cause of this disease, which is manifest on roots and basal parts of canes, does not seem to have been isolated and described heretofore.

The disease is produced by a strain of *Collybia dryophila*, Fr. This fungus may be isolated from diseased roots and infected areas on canes by transplanting parts of rhizomorphs, mycelium and infected tissues to prune agar. The mushrooms of the fungus have not been found in nature, although a diligent search was made for them in the infected dewberry fields during late autumn and early winter. Except under very favorable conditions they probably do not develop on the dewberry plant under field conditions. This is not necessary for maintaining the life of the organism, since the mycelium easily lives over in the bark and other tissues of dewberry wood.

The mushroom was developed in large and satisfactory numbers in pure culture from which the descriptions in this paper are taken. In two months, fifty-eight plants were grown to maturity in six flasks of two liter capacity, and others are constantly appearing on the new rhizomorphs, which continue to develop in flasks that have already produced several crops of plants.

Plant solitary, gregarious or subcaespitose.

Cap 2–8 cm. broad, mostly 4 to 5 cm., gibbous, margin incurved, sometimes reflexed at maturity, uneven, smooth, subhygrophanous, dull, rarely shining, not greasy or viscid when moist. Color tan to some shade of brown, uniform on most plants, but changing to deep brown at center of cap at maturity. Flesh thin, soft, pliant, whitish. Odor like rotten wood, fungoid. Taste mild, agreeable, edible.

Gills very thin, adnexed, nearly free, crowded, sinuate, edges uneven,

[1] Published with the approval of the Director of the North Carolina Experiment Station as paper No. 20 of the Journal Series.

white, pallid, or creamy shades, at maturity turning to faint ochraceous. Slight reddening of broken edges sometimes, but not definite.

Stem 3–15 cm. long, mostly 7 to 10 cm., 2–10 mm., thick, mostly 4 to 8 mm., equal except for a sudden enlargement at the very base, where the diameter is sometimes 20 mm., smooth, white-tomentose at base and near cap, sometimes on entire stem and cap; stuffed, pithy, then hollow in some plants. Color whitish changing to shades of brown resembling that on pileus, cuticle fibrous. Striations prominent, and distinct throughout. Rhizomorphs numerous, well developed, white, creamy, tan and shades of brown.

Cystidia none.

Basidia club-shaped, with four sterigma.

Spores hyaline to faint buff and without an oil drop when mature, pip shaped, smooth 3.5–4.5 x 6.0–8.5μ, mostly 4.0–8.0μ.

Excrescence, a cerebriform-like hymenium, with basidia and spores developed on rice medium but not on any part of stem or cap.

Mushrooms readily developed on cooked dead Lucretia dewberry roots and stems moistened with cooked prune medium when maintained at 25 degrees centigrade in candle or day light. Period of growth before fruiting began was one to three months.

Slight variations were noted between this parasitic strain and other plants of *Collybia dryophila* as described by Kauffman, Coker and Beardslee and McIlvaine and MacAdam and others. All of these investigators agree, however, that variations in *Collybia dryophila* are apt to be very great. The definite uniformity observed in regard to the important morphological characters of the mushrooms developed in pure culture has been so pronounced as to suggest the use of the pure culture method as a means of solving the difficult question of varietal relationships in such perplexing groups as that represented by *Collybia dryophila*.

It has been shown in many cases that plants of *Collybia drophila* are depressed around the center of the pileus. This character is clearly shown in illustrations by Coker and Beardslee and McIlvaine and MacAdam. This character, however, is not always dominant since Kauffman shows no special depression of the pileus in an excellent illustration of the species. In this respect the species is more nearly like that of the parasitic strain described in this paper, since no depressions were found in any of the plants obtained in these studies, and in nearly all cases the plants remained somewhat gibbous when fully matured. The margins were sometimes reflexed, but never obtuse.

The very definite striations on the stems may also be considered with

some emphasis, since these seem to be more demonstrative than was reported in other descriptions. These were prominent to the naked eye on young plants and became more showy as the plants matured. The undesiccated striated stems could easily be twisted into many loose stringy fibers. Tomentose hairs on both stem and cap of some plants were quite prominent. Their prominence may have been a response to cultural conditions.

The length of the stem was reported by Kauffman and by Coker and Beardslee to be 3–6 cm., and 4–7.5 cm., respectively. These lengths are much shorter than the stems of plants of the parasitic strain developed in pure culture. It is reasonable to believe, however, from data obtained in these studies and given above, that the maximum length that stems may attain is apt to be variable and misleading if taken as a criterion in descriptions, unless the maximum and minimum lengths are always discovered.

When tissues of the flesh, gills, and stems are closely observed under the compound microscope it is very well demonstrated that the entire plant is homogeneous. The cuticle of the stem consists of many long septate parallel filaments, and the inner tissues are of mostly the same structure except that they show more pronounced twining. The flesh and gills are made up of the same kind of filaments. All parts are shades of white except a very thin layer on the top of the cap, which has the pigment shades of tan and brown.

The spore measurements, while slightly larger than those reported by Coker and Beardslee, are close to those given by Kauffman and by McIlvaine and MacAdam. The shape conforms with those described and drawn by Coker and Beardslee, except they are slightly more pip shaped. When immature spores are broken from the basidia, parts of the sterigmata are sometimes attached. These were first confused as being part of the spore tip. The sterigmata were very long on some basidia, and short on others, furthermore, some sterigmata were short and others long on the same basidium.

The variations between the strains parasitic on dewberries and plants described by others may seem to some mycologists to be sufficiently great to justify the erection of a new species. Dr. C. H. Kauffman of the University of Michigan to whom specimens were submitted placed the plant in the *Collybia dryophila* group, but said that it was not a true *dryophila*. A careful comparison of the characters of the dewberry strain with the characters given in Dr. Kauffman's excellent description of *Collybia dryophila* leads unquestionably when, as mentioned above, a few morphological differences are compromised to the conclusion that

the plants are very similar. Furthermore, comparisons were made with the specimens collected by Dr. W. C. Coker of the University of North Carolina, who is also of the opinion that it is a variety or strain of *dryophila*. Dr. George W. Martin of the University of Iowa also identified the plant as belonging to the *dryophila* group.

The fact that the *Collybia dryophila* causes a disease of dewberry warrants publication of a fully illustrated detail description of the parasite. The range of the parasitic form of the fungus is as yet unknown. In many instances diseases which have been attributed to *Armillaria mellea* and to *Clitocybe monodelpha* solely on the basis of the character of the rhizomorphs found on the diseased parts, especially if they are shades of tan and brown and not black, may as well be attributed to *Collybia dryophila*. At least the matter is worthy of further study.

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EXPLANATION OF PLATES

PLATE 5

Fig. 1. *Collybia dryophila* mycelium in manure cultures in four central tubes, on prune agar in large tube on right.

Fig. 2. The buttons and small mushrooms growing on old dewberry roots saturated with prune medium in two liter flask.

Fig. 3. The same mushroom 48 hours later.

Fig. 4. The same mushrooms, showing general character of cap, flesh, gills, and stems, which are very much distorted due to being crowded in the flask.

PLATE 6

Fig. 1. Mushrooms showing gibbous caps, white striations, uneven margins; with imprint of gills on edges; also crowded gills, many short, and the smaller stems.

Fig. 2. Mushroom showing color of flesh and gills, their thickness, the color of the inner tissue of the stem, and the prominent striations.

Fig. 3. Mushroom showing tomentose cap, and stem, also abundant development of rhizomorphs.

Fig. 4. Mushroom air dried, showing wrinkled croqueted cap, wavy gills, twisted, and brittle stem.

PLATE 7

Mature basidium and spores; pip shaped spores; and paraphysis with many vacuoles

PLATE 5

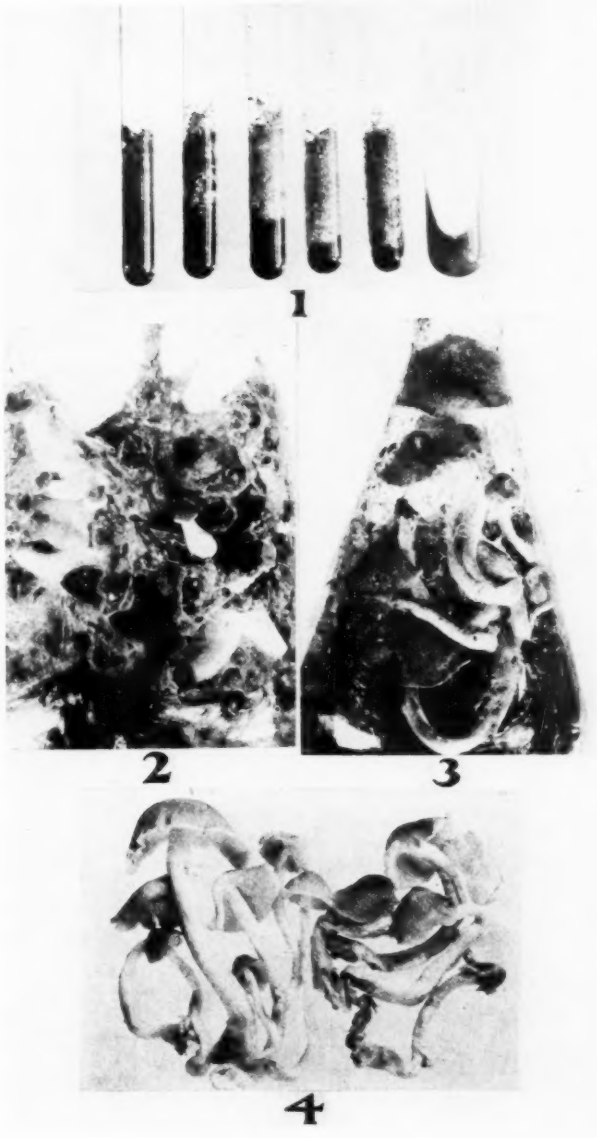

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PLATE 6

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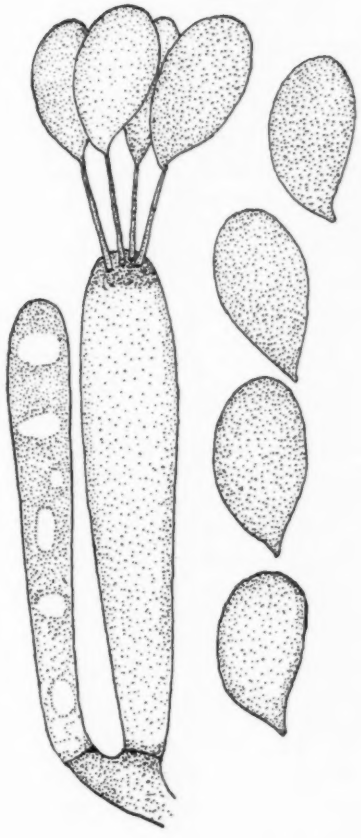
PLATE 7



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A STUDY OF DIRECTION TRENDS IN MAZE LEARNING OF WHITE RATS

By JOHN C. BAGWELL

Earlier experimental work suggested the possibility of white rats using a sense-of-direction factor in learning a maze. The problem undertaken here is one of placing the animal's direction-activities under experimental observation and control; and to determine if possible what receptors an animal might be using under such conditions. A multiple-choice maze design was used where an animal could take any one of a number of possible correct pathways to its food box.

It was observed that once the food had been found and the maze traversed a few times, the animals followed widely different paths on successive runs; but the paths practically always involved turns in the direction of the food goal and seldom in a direction away from it. The question then arises: How can an animal run along entirely new pathways and at the same time remain oriented to its ultimate objective, making seldom any turns not in the direction of the latter? This is only a different way of stating the old problem of homing. How can homing pigeons which have been carried far from their nesting grounds return over a territory entirely new to them? How is it that the family cat which has been carried miles from home is able to find its way back in a very short time? How does the dog return home to his former master after being carried for miles away to the home of his recent purchaser? And how do bees return to their nests after explorations? These are questions which have never been adequately answered. This same type of behavior is here shown by the rats in the maze. The principle problem of this research was to determine, if possible, what sensory cues were used by the animals in such behavior.

The nature of the controls used in this experiment to determine the cues used was that of changes in environmental factors. Once the animals had established certain reactions to environmental factors, certain elements of the total situation were changed and the accompanying effects upon the animals noted.

These changes were: at the end of each five trials the maze was rotated 90° to the right, and in addition, at the end of each ten trials the cardinal direction through the maze was changed—the two procedures

eliminating all constant stimuli acting upon the animals from within or without the maze. These changes were followed often by the animals' taking an entirely different pathway from the preceding trial and yet making few or no errors in reaching the exit—the same as was true on trials after no change had been made. Such would tend to prove that the animals were not reacting to *visual* cues in threading the maze. For *olfactory* control: at the end of each twenty trials the food box was thoroughly cleaned and food was placed in another box alongside the maze. From this position the air above the food was blown across the maze with an electric fan. If the animals were reacting to the smell of food, it is to be expected that under such conditions the animals would have gone to the side of the maze where the food was, instead of to the former feeding place. The animals continued, however, to go to the proper exit without noticeable changes in behavior. For *auditory* control: each animal was removed from the food box after a trial before running the next one in order that it might furnish no guiding sounds. At no time during the experiment could there be noticed any evidence of auditory stimulation operating as a cue for the animals.

The above summary has been in the form of a negative answer to our problem. It is apparent that the animals were not using visual, olfactory, and auditory receptors in finding their way to the food box. The question then arises: what equipment has the animal that functions in permitting this peculiar form of behavior? If the visual, olfactory, and auditory receptors do not act as guides for the animals, then just what other receptors are left to offer an explanation? It is obvious that tactual receptors could not perform such a feat. There is left then the rôle of kinesthetic and organic factors involved. Watson found that an animal's learning of a particular given path through a maze could be reduced to the rôle of kinesthetic and organic senses; that is to say, that an animal whose visual, auditory, and olfactory receptors are removed by operation, and tactual factors likewise controlled, can still learn a given path through a maze. But the problem here is quite different. It is not the sensory equipment necessary for learning a *single* path that we are seeking to discover, but instead, it is the sensory equipment that subserves the function of this apparent sense-of-direction which the animals have demonstrated.

The explanation seems to resolve itself into the part played by kinesthetic and organic factors. Speculatively, this appears to be in the form of a kinesthetic and organic set which an animal establishes when first entering the maze—a preparatory orienting response to the maze situation determined by the entrance alley. This orientation is in a

given constant direction from the entrance. Then as the animal traverses the maze, any reaction that is a deviation from this original set has associated with it a tendency to react in the opposite direction. There would be then compensatory movements to the right and left with reference to the original kinesthetic and organic set which would permit a variation in the pathways taken on successive runs.

There is a significant suggestion from our results that bears upon the general conception of habit forming. In forming a habit of this kind, there is not an integration of several particular reflexes, but instead, there is the formation of a hierarchy of part-habits. The higher level of this habit finally manifests itself in a general direction habit which allows a certain amount of variation in its function. Finally, as the animal enters the maze the response is not one to particular twists and turns of the maze, but it is a complete response to the direction of the food box.

The findings of this experiment suggest a number of problems. In this experiment, as heretofore noted, the controls were secured by experimental manipulation of environmental conditions. A continuation of this same work would take the form of operative technique. This would consist of elimination of the animals' sense organs, and to see what part these receptors play in the direction activities of an animal. If it could be demonstrated that an animal still shows this sense of direction after the removal of all receptors possible, this influence in the field of learning would be obvious. Also, an explanation, partial or complete, would be possible for the way in which an animal finds its way back home after being carried some distance away. To merely say that an animal has an homing instinct is to say no more than "the cat came back."

A problem arises in this connection with human behavior. Suppose one go down town by way of several streets which twist and turn from the true direction. This path is familiar to him and he experiences no difficulty because he has traversed the route so many times. The question arises as to just how he does this. Does vision subserve such a function? Does audition? Or any other sense organ? If certain receptors are the means to such an end, are they absolutely necessary for him to find his way down town: Such questions can be attacked in the psychological laboratory. A maze suitable to the use of human subjects can be constructed. The subject can be permitted to learn the maze, and then controls over the various receptors can be used to determine their significance in traversing the maze again. The further data from the subjects' introspections would doubtless be of value here.

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FERTILIZATION AND OOGENESIS IN ACHLYA COLORATA[1]

By Paul M. Patterson

Plates 8–10

Historical

Fertilization and nuclear behavior in the sex organs of the *Saprolegniaceae* was only partially understood before Humphrey's time; and indeed, several important points remained undemonstrated until Trow's good works cleared them up.

Humphrey ('93), using *Achlya americana* and *A. apiculata*, cut paraffine sections and confirms De Bary's conclusion that there is no transfer of material from the antheridium to the oogonium. He sees no nuclear division and concludes that none occurs. Also, he says: "The observed reduction in the number of nuclei is plainly due to nuclear fusions, ... probably many times repeated, but whether all of the original nuclei are involved in these fusions, or whether some of them degenerate and disappear . . . . is uncertain" (pp. 92–93).

Hartog ('95) also sees no fertilization, and is very sure that nuclear fusions, instead of degeneration, reduce the original number of oogonial nuclei.

Trow ('95) claims that the supernumerary oogonial nuclei do not fuse but disappear by degeneration. He also claims that "in the oogonia and antheridia, each nucleus undergoes one reducing division by an indirect method, in virtue of which the whole chromosome becomes a half chromosome, but no fusions of functional nuclei take place" (p. 648). He claims that fertilization takes place in *Saprolegnia mixta*, *Achlya americana*, and an undetermined species of *Achlya* on the ground that the young oosphere is uninucleate, later becoming binucleate, and all of the old oospores are uninucleate again.

Hartog ('96) objects to Trow's conclusions as ill-founded, and claims that there is no positive evidence for fertilization. He restates here his belief in nuclear fusions in the oogonium.

[1] A thesis, submitted in partial fulfillment of the requirements for the degree of Master of Arts, University of North Carolina, June, 1927.

Trow ('99) studies the subject again, using *Achlya americana* var. *cambrica*, and restates his belief in fertilization on the same grounds as he did in his ('95) paper. He also observes nuclear degeneration again.

Again Hartog ('99) takes issue with Trow, restating his previous views.

Trow ('01) worked with *Pythium ultimum* in order to gain practice in studying degeneration of nuclei where they are known to occur, and then in ('04), made a fine investigation on the degeneration of nuclei, and definitely established fertilization in *Achlya deBaryana*, and *A. polyandra* Hildb. He also claims evidence here for a second mitosis occurring in the oogonium, which he thinks is probably reductive.

In the meantime, Davis ('03) worked on the apogamous *Saprolegnia mixta* where he offers what he considers evidence against the occurrence of fertilization, by noting cases of binucleate oospheres. He also gives evidence for his view that the oogonial division is not meiotic, which has come to be an accepted fact.

Claussen ('08) demonstrated fertilization, and agrees essentially in all points with Trow except for the second oogonial mitosis, which has never been seen since; and he also denies the meiotic nature of the oogonial division, stating that it probably occurs in the germination of the egg. Claussen notes that in *Saprolegnia monoica* most of the nuclei in the antheridium and oogonium degenerate, the division entailing only a few surviving nuclei.

Mücke ('08) and Kasanowski ('11) working with *Achlya polyandra*, De Bary, and *Aphanomyces laevis*, respectively, confirm Claussen in all essential points.

This work on *Achlya colorata*, undertaken for the further confirmation of the procedure of oogenesis and fertilization, was done in the Botanical laboratory of the University of North Carolina, under the direction of Dr. W. C. Coker, for whose suggestions and encouragement, the writer wishes to express his sincerest gratitude. The writer also wishes to acknowledge his indebtedness to Dr. J. N. Couch for the use of his schedule for Gram's stain.

MATERIAL AND METHODS

The material used was *Achlya colorata* found by Miss Velma D. Matthews in Battle Park, Chapel Hill, N. C., in a water culture, January 1926. Pure cultures were obtained by isolating a single spore and making cultures from its resultant mycelium. This culture was kept by making occasional transfers to agar media. In the summer of 1926,

the culture became infected with bacteria and Ascomycetes, and all of the mycelium was killed, leaving many eggs in the agar. Further cultures were taken from various localities to obtain *Achlya colorata*, and in November it was procured from a soil culture taken from under a bridge, a mile from Lakeview, N. C. Previously, many experiments were carried on to germinate the eggs in the infected culture, and at about the same time that *A. colorata* was found from a soil culture, the eggs which had been resting about three months were germinated by centrifuging them for 45 minutes. The centrifugal force seemed merely to incite immediate germination, for after three and a half months, the eggs began germinating of themselves, and at the end of four and a half months, all had germinated. The germinating egg developed a hyphal tube that soon branched and formed a mycelium. Only about 70–90 per cent of the eggs centrifuged, germinated. Only a very few germinated if the centrifuging time fell below 45 minutes. All of the observations made on germinating material for this paper was taken from this single culture.

Achlya colorata taken from the sprouting material, was grown on various media, as bits of boiled corn grains, split hemp seeds that had been boiled, white of egg and on mushroom grubs, but with the exception of a few cultures on hemp seed, scarcely any oogonia were produced, though hundreds of cultures were made. It was then grown on various agars, as bread agar, maltose-peptone agar, corn meal agar, but no oogonia were produced in the media, and when blocks of the agar containing the mycelium were transferred to water, only sporangia were produced.

Experiments based on Pieter's work ('15), especially tables III and IV, (pp. 542–543), that deal with *Achlya racemosa* were repeated in part and in modification. Dry peptone sold by Arthur H. Thomas was made into various solution strengths in distilled water, corked with cotton plugs in 100-cc. bottles, and autoclaved at 20 pounds pressure for 30 minutes. Inoculations were made with bacteriological precautions from a bacterially free mycelium, that was actively growing on a maltose-peptone agar plate. Inoculation from cultures grown in a peptone solution entirely inhibited oogonial production while the mycelium was still in the solution. Peptone strengths of 0.062, 0.084, 0.1, and 0.125 per cent, produced very scanty mycelia, but enormous numbers of oogonia in the solution in 3–4 days. With higher percentages of peptone, mycelia were strongly developed, but oogonia and sporangia were induced to appear only by a transference of the material to water. When the mycelia from a 0.5 per cent peptone solution were transferred

to water, many sporangia and oogonia in about equal numbers appeared; mycelia transferred from 1 and 2 per cent solutions produced practically no oogonia in water, but many sporangia. The disadvantages to this mode of culture are that the oogonia produced in the solution are small, and that there was generally only one egg formed to the oogonium, though often two; and also that antheridial production was often largely inhibited. The advantages are that cultures absolutely free from bacteria were easily grown, and that oogonia are certainly and abundantly produced. Autointoxicating metabolic by-products may be overlooked as far as their effect upon the growth of the oogonia are concerned, since there is merely a weft of mycelium in the bottom of a bottle, and it is removed in 3–5 days; whereas mycelium seems still to be healthily growing at the end of 7 days in a 2 per cent solution where the mycelium has completely filled the bottle, and the metabolic waste materials are necessarily very much more concentrated.

Later another attempt was made in culturing *Achlya colorata* on hemp seed with the result of the production in every case of an abundance of oogonia, with antheridia; producing mostly three, often 2–5 eggs to the oogonium. The conditions were the same as when hemp seed were tried earlier in the work, and the factor governing the oogonial production in this case is unknown. Observations were made on material grown on both media, and reference to such environmental difference will be made during later discussions.

The material was fixed for 24–36 hours at different stages of growth at different times of the day in the following chromo-acetic solutions:

a. Davis' formula: Chromic 0.025 per cent; Acetic 0.1 per cent.
b. Trow's formula: Chromic 0.7 per cent; Acetic 0.3 per cent.
c. Stephen's formula: Chromic 0.8 per cent; Acetic 0.5 per cent.
d. Claussen's formula: Chromic 0.5 per cent; Acetic 1.0 per cent.
e. Claussen's formula diluted a third.
f. Claussen's formula diluted a half.
g. Chromic 0.45 per cent; acetic, 0.75 per cent.

All of the formulas are good except that (a) is rather weak, and that (c) and (d) caused a little plasmolysis. Most of the observations made were on materials fixed with (g).

After the material was washed for 24 hours, the mycelium was balled up in a dry petri dish, and the excess water in the mycelium removed by touching the mass with a blotter. 1 per cent agar in water previously melted and cooled to 100 degrees F. was poured over the balled-up mycelia, and when the agar had set, the mold was removed, freeing it

from as much agar as possible. Thus damage to the oogonia during subsequent handling is avoided, and as the mycelia remain in compact wads, blocking in paraffine is facilitated. The material was dehydrated in alcohol, cleared in xylol, and infiltrated in 62 degree paraffine, a very gradual series being used throughout.

Serial sections were cut from 3–10 microns thick with a Bausch and Lomb rotary microtome, using a Keen-Kutter razor blade in a holder. Most of the sections were cut 4 and 5 microns, which is sufficiently thin.

Sections were stained on the slide in the following stains:

a. Haidenhain's haematoxylin, made up by the slow method.
b. Cole's rapid haematoxylin (Cole, '26).
c. Delafield's haematoxylin and erythrosin.
d. Saffranin and orange G.
e. Gram's stain and orange G.

The last gave the best results, and most of the observations and all of the figures were made from the material stained in Gram's and orange G. (Gram's stain: 1 per cent aniline solution of gentian violet; iodine solution-2g potassium iodide, 1g iodine, 300 cc. of water; 1 per cent orange G. in clove oil).

DEVELOPMENT OF THE OOGONIUM

The oogonial initial. The oogonium may be formed as an intercalary, terminal, or, in the great majority of cases, as a lateral growth on a short stalk. At first it is elongated and oval (fig. 1); later it becomes rounded as it arrives at full size. Papillae make their appearance at an early stage (fig. 1). A very few oogonia bore no papillae when grown in a peptone solution. The papillae appear as an outgrowth of the oogonial wall; there is no thickening of the wall at this point, but there is a space filled with oogonial protoplasm within each papilla. The number is very variable, ranging from 1–2 to 8–10, or more.

Unless otherwise stated, the following observations on the oogonial development were made from material grown in peptone solutions.

The oogonial initial commences in about three days after inoculation. As it is formed, vacuolate protoplasm streams in the stalk and in the oval-shaped inflow at the base of the oogonium, but becomes very dense as it is packed into the enlarging oogonium (fig. 1). In material grown on hemp seed, there is generally, though not always, a central vacuole formed as the protoplasm enters the oogonium, and this may or may not be in connection with the central vacuole of the stalk. In peptone material there is generally no vacuole formed before the oogonium has

attained full size. A streaming appearance of the protoplasm, with vacuoles elongated in the direction of the protoplasmic flow characterize the early oogonial stage. Along with the protoplasm a large number of nuclei are carried into the oogonium: 150–200 of them; more in large oogonia, and fewer in small ones. Only the number of nuclei originally present in the given amount of protoplasm that enters to form the oogonial content are there present; that is, there is no migration of nuclei from other portions of the mycelium. This conclusion is supported by the fact that in certain environments, e.g., in a 1 per cent peptone solution, all of the protoplasm is used to form oogonia, and in such cases there is no residual protoplasm to furnish additional nuclei. Of course as the protoplasm leaves a hypha, there is a very thin film of protoplasm left on the hyphal wall, in which lie a few flattened, scattered, nuclei. Those that enter the oogonium are purely vegetative, and are very small, measuring from 1–1.5 μ in diameter.

This inpouring of protoplasm continues until the oogonium has attained full size, and then a cross-wall appears at a considerable, but varying distance down the stalk below the oogonium proper. Sometimes the septum cuts the stalk below the antheridial origin, but more often, above. The septum is very thin at first, but soon thickens, often forming a conspicuous solid papillate growth into the oogonium.

The protoplasm in the oogonium quickly becomes evenly distributed now; the streaming appearance is lost; the small elongated vacuoles have rounded; the cytoplasm is dense; and the nuclei are evenly distributed throughout the whole mass.

The oogonial wall, at first very thin, thickens slowly, and by late peripheral stage has acquired its full thickness of approximately 1.5–2.5μ

Structure of the nucleus. The structure of the nucleus in the spireme stage is marked by a deeply staining, more or less central, chromatic body that we shall term here for convenience the *nucleolus*, though justly objected to by Trow on the ground that it represents the whole of the chromatic mass of the nucleus. About the nucleolus there is a hyaline nuclear-plasm, delimited by a nuclear wall. From the nucleolus to the nuclear wall radiate a varying number of linin strands that show a thickening at the points of their attachments to the nuclear wall (figs. 17 and 34). Chromatic granules were occasionally seen scattered along the nuclear wall, a fact also recorded by Smith ('23).

Degeneration of the primary nuclei. By the time the septum is formed in the neck of the oogonium, and often before, a large majority of the nuclei in the oogonium have begun degeneration, but not disorganiza-

tion: they merely commence to dim, that is, they lose some of their power of retaining gentian violet. However a varying number of the original nuclei, 8–12 or more in number, begin about the time the rest start degeneration, to enlarge in all of their parts, and stain more intensely than the degenerating nuclei. The primary nuclei of the peptone material continue to degenerate slowly, and their structure can still be seen in the maturing oospore. In hemp material the parts of the nucleus quickly dim and become unobservable. By the time the mitotic division occurs only a faintly stained nucleolus is observable, and this a little later becomes confused with protoplasmic granules. Thus their identity is lost and it appears as though they are digested by the surrounding cytoplasm. Previous observations by various men have been the same as that described for the hemp seed material, and their views may be summed up in Kasanowski's account as typical: "The rest degenerate: they become smaller, the nuclear membrane, the nucleus, and nuclear network become invisible, until finally a great number of small, colored, chromatin-like bodies remain in the protoplasm." Reference to the primary nuclei as observed in the peptone material will be made in connection with the other developments as we proceed.

Protoplasm in the peripheral stage. By peripheral stage is meant that period of oogonial development when the cytoplasm having become vacuolate in the center, resolves itself into a peripherally arranged hollow sphere of protoplasm. Unless there is already present a vacuole in the oogonial initial, the oogonial vacuole commences by the central small, protoplasmic vacuoles enlarging and anastomosing. The vacuoles just without these commence enlarging also, and the process continues until there is a large central vacuole, which soon loses its appearance as such owing to the injutting of other enlarging vacuoles. In case the oogonial initial already has a central vacuole, the process of enlarging is the same. Cytoplasm, it would seem, has begun degeneration, dissolving itself, as it were, into a colorless fluid. This continues until the central vacuole has enlarged to about one-half the diameter of the oogonium. The formation of vacuoles now becomes very obscure, and the cytoplasm is becoming thinner and taking up less stain. Toward the end of the peripheral stage, most of the bulk of the protoplasm is degenerating nuclei (figs. 4, 6, and 8). During this time the primary nuclei continue to dim. In hemp material little can be observed concerning the primary nuclei at this stage. The primary nuclei are represented by the dark dots in fig. 5; they have completely disappeared

in fig. 10. Claussen, Mücke, and Kasanowski found that the central vacuole came into being before the oogonial septum was formed. Claussen and Mücke found that the oogonial vacuole was in open communication with the central vacuole of the oogonial stalk, but Kasanowski did not find this to be the case with *Aphanomyces laevis*. As stated above, both of these cases were found in *Achlya colorata*.

The peripheral protoplasm continues to thin, and references will be made to it later.

Division of the nuclei. The vital nuclei, as we may term those that are set aside for further activity, having enlarged to 3.5–4μ, and lying fairly evenly distributed in the parietal cytoplasm, now undergo indirect division. This division, as in figures 2 and 3, generally occurs in both the antheridium and oogonium at the same time, each nucleus being in exactly the same stage as any other; but sometimes the different nuclei will be in different stages of mitotic division in the same oogonium. Mitosis is intra-nuclear. The chromosomal number is very probably three (figs. 25, 26, 27 and 28).

Indirect division proceeds as follows. The nucleolus dilates, and rounds up into three (?) chromosomes, that are closely associated with each other, and lie in the middle of the nucleus (fig. 25). The chromosomes are rodshaped, and in one case (fig. 26) the chromosomes were curved with their concave side facing the nuclear membrane. The central one appeared straight. The nucleus becomes elongated, and spindle fibers appear in its long axis, radiating from a centrosome. No astrospheres, or astral rays were seen. There seemed to be only three spindle fibers, the same number Trow ('04) observed in his material. Figure 27 shows anaphase, figures 28 and 29 show telophase, with the chromosomes rounding up into nucleoli; the nuclear membrane has reappeared. Invariably, after mitotic division, and reappearance of the nuclear membrane, there were two chromosomal aggregates, with linin strands radiating from them (figures 30, 31 and 32). Nuclei like that shown in figure 31 persist for some time in hemp material, but soon change in peptone material. In both cases, the final nuclear stage is like the nuclei in figure 4 or 34, thus giving the impression that division into daughter nuclei occurs at a time when the nuclear membrane has reappeared, linin network reformed, and the nucleoli have become fully chromatic, though actual constriction into daughter nuclei have not been demonstrated. Figure 34 shows the typical daughter nucleus, though there is sometimes an additional chromatic granule as in figure 33, which Mücke thinks is a centrosome. A similar

granule is seen in figure 32 before the constriction into the daughter nuclei.

Trow ('01) claims that a second mitosis occurs in the oogonium. We have observed clearly only one case that might possibly lend itself to this interpretation. It is the nucleus shown in figure 21, which if there were any other evidence to support it might be considered a condition in which the first division was followed immediately by a second, within the same nuclear membrane. From what we have seen, a second division is highly improbable, and no other worker has confirmed it.

The daughter nuclei formed in the oogonium by the general division of the vital nuclei will be referred to below as the secondary ones in contradistinction to the mass of smaller, degenerating nuclei, the primary ones. The secondary nuclei are about 3.5μ in diameter and they retain their staining ability until late peripheral stage.

Degeneration of the secondary nuclei. As is evident, division of the vital nuclei to form secondary nuclei produces many more than are required for the formation of eggs. In most cases of the peptone material, only one or two eggs were formed, sometimes three. Thus all but one, two, or three of the secondary nuclei degenerate. Trow ('04), in working with *Achlya De Baryana*, states that "degeneration may apparently commence either when the nuclei are in resting condition, or when in the prophases, or even in the metaphases of mitosis." And Kasanowski notes that "These daughter nuclei lying at the poles, still connected by the spindle, suddenly degenerate without reaching resting stage." However none of the nuclei of the peptone material start degeneration before late peripheral stage. In hemp material, degeneration commenced sometimes rapidly, but the daughter nuclei had always fully rounded up, first. After fertilization in peptone material, the primary and secondary nuclei are still seen where the staining has been good, the primary ones very faint, and the secondary ones only a little altered. Degeneration is marked merely by a beginning of an inability for them to retain gentian violet (figs. 8 and 18).

The surviving nuclei become associated in late peripheral stage with a mass of dense protoplasm that makes its appearance a little before the oogonial protoplasm balls up about the ovacenters.

Formation of the oospheres. When the parietal protoplasm, the bulk of which is primary and secondary nuclei, has become very thin (fig. 6), the oogonial content collects about one or more of the surviving nuclei. This process is very rapid, and as the peripheral layer between these

egg centers becomes thinner and thinner (fig. 9) it masses into spherical balls with the surviving or female nucleus at its center. Thus the oosphere consists of a large deeply staining nucleus in the center that is surrounded by a mass of denser, ill-defined protoplasm, which thins out toward its periphery. This denser mass is usually small, but, as seen from our figures, it varies so much in size, density and definition that except for the fact that it corresponds to what has been called a "coenocentrum," we would hardly think it worthy of a special term. The bulk of the oosphere is the degenerating nuclei arranged in a homogeneous mass (fig. 18) or, more often, arranged in fibrils radiating from the coenocentrum enclosing radially elongated vacuoles (fig. 12). The persistence of the primary and secondary nuclei until the maturation of the oospore has not been shown in many of the figures, though they can always be seen in peptone material. Fig. 10 shows the typical oospheres of hemp material. Here all of the nuclei but the female nucleus have degenerated. The persistence of the degenerating nuclei of the peptone material has no counterpart in previous observations.

No fibers radiating from the small end of an oval nucleus, as observed by Claussen and Mücke, were seen. In *Achlya colorata* the nuclei were invariably spherical, and typically with the nucleolus in the center, though other granules were sometimes present.

The coenocentrum is present in the other species of the *Saprolegniaceae* studied by various men. It is comparable to the same body in the *Peronosporaceae*, as is illustrated for instance in Stevens' and Wager's works. Davis ('05) was the first to homologize the similar structures. Supporting the view that the coenocentrum is of a chemotactic nature, attracting the male nucleus, is the fact that the male nucleus will pass what seem to be normal secondary nuclei, and make its way to the coenocentrum.

Before fertilization occurs, there is a very thin but readily demonstrable membrane surrounding the oosphere.

DEVELOPMENT OF THE ANTHERIDIUM

Shortly after the oogonial initial has begun enlarging, one, two, or sometimes three tube-like protuberances grow off the oogonial stalk or the base of the oogonium. They elongate, growing in an arc toward the median portion of the oogonium proper, until they touch, the oogonium forming a receptive papilla at the point of contact. The antheridium continues to elongate after it touches the oogonium, resulting in a bulging of the tube into a semicircular or ellipsoid curve.

Most of the observations here are made with hemp material.

Protoplasm enters the antheridium as the tube elongates, but is not very dense: sometimes retaining at first the thready structure characteristic of vegetative hyphae. Quite a number of nuclei enter the antheridial initial, their size being from 1–1.5 in diameter—the same as the primary nuclei of the oogonia. A septum constricts off the antheridium at a variable distance from its origin. All of the nuclei quickly degenerate except about 1–6, which undergo a division at the same time and in the same manner as the vital nuclei of the oogonium (figs. 2 and 3). In peptone material, most of the antheridial contents were seen to be degenerating nuclei, as in the oogonium. While the oogonial peripheral protoplasm is thinning, there seems to be no change in the antheridial contents. The daughter nuclei of the oogonium enlarge to the size of the mother-nucleus, while after division, the nuclei remain small: about 1.5–2μ in diameter.

During the late peripheral stage of the oogonium, there is a pore formed in the oogonial wall under the point of antheridial contact, small, at first (fig. 7) but enlarging, and by the time the oogonial protoplasm balls up into oospheres, part of the tip can be seen bulging through it (fig. 12).

The fertilization tube is of various sizes, single or branched, and grows off the portion of the antheridium protruding into the oogonial cavity (fig. 12). It is an extremely thin-walled tube, often taking a tortuous course to the oosphere (fig. 11).

FERTILIZATION

The fertilization tube touches the oosphere, which now possesses an extremely thin membrane about it. It seems that the tip of the tube and the oosphere membrane in contact, dissolve away in this region, but leave the edge of the tube firmly attached to the edge of the pore formed in the oospheral membrane (fig. 15). The male nucleus is not equal to the diameter of the tube (figs. 11, 12 and 15). There may be more than one nucleus in the tube (figs. 11 and 15), but only one was seen to enter the oosphere (fig. 14). There is not much cytoplasm in the tube, and very little enters the oosphere. Mücke describes a male nucleus that is as large or larger than the diameter of the tube, being forced out by pressure from the antheridium.

The male nucleus migrates quickly to the coenocentrum, and has enlarged considerably before half-way reaching it (fig. 16). By the time it has reached the female nucleus, it is indistinguishable in size

and staining qualities from the female nucleus (figs. 17 and 18). The two nuclei lie side by side imbedded in the coenocentrum, often pressed so tightly together that their area of contact is a plane almost equal to their median section. They remain in this condition for a considerable time: until the oospore wall has acquired nearly half of its ultimate thickness, as observed in one case (fig. 19). Complete fusion then occurs, and the oospores are uninucleate (fig. 20).

MATURATION OF THE OOSPORE

The vacuoles of the oosphere round up into equal sized globules containing oil (figs. 16 and 19) and are arranged in two or three concentric rows about the periphery of the oospore. This gives the egg the characteristic centric arrangement of oil droplets, that is used in its taxonomy. In peptone material fatty bodies were seen (fig. 19) containing the characteristic nuclear structure. Evidently the nuclei in their degeneration form oil. Very dense protoplasm fills the center of the oospore (fig. 20).

The egg-wall is slowly added to from the inside until it becomes about 5μ thick. The egg-wall is smooth on the surface and is structureless in cross-section.

GERMINATION

The first indication of germination is manifest by a slight transparency of the egg. The oil droplets become emulsified, or absorbed by the dense central protoplasm. The thick egg-wall is digested, and by the time the nucleus of the egg has divided five times, the egg-wall is merely a thin membrane (fig. 22). The wall is never completely absorbed, but in this thin state, is ruptured by the growing, and swelling egg, (fig. 23). A central vacuole is formed in the egg by the 32-nuclear stage: earlier stages have not yet been studied. The egg sends out a tube, the beginning of which can be seen in figure 23, and more distinctly in figure 24, the latter being in a 64-nuclear stage. More than one tube may be sent out by the germinating egg; this tube soon branches to form a mycelium. The nuclei are as small as those noted at the beginning of the paper for the nuclei of the hyphae; and the protoplasm is finely granular. Though it has never been demonstrated, the fusion nucleus of the egg is considered to be diploid, and the first division of the egg nucleus is supposed to be reductive, making the rest of the life cycle haploid.

CONCLUSION

The work confirms the general development and many of the details as given by recent workers for other species of water molds. However, it was found that changes in cultural media resulted in variations in the time of origin of the central vacuoles; size, form, and persistence of nuclei; size of oogonia; number and size of eggs, and antheridia; time of appearance and size of coenocentrum; and other details.

As the oogonial and antheridial initials are formed, a large number of nuclei along with cytoplasm enter them. When they have attained full size they are cut off by cross walls. As a central vacuole is being formed in the oogonium, most of the nuclei degenerate, and a division of the surviving nuclei takes place simultaneously in the antheridium and oogonium. The number of chromosomes seems to be three. These daughter nuclei degenerate in the oogonium, as the peripheral protoplasm thins, with the exception of one for each egg that is to be formed. Each female nucleus becomes associated with a coenocentrum, and the oogonial protoplasm balls up about each nucleus, thus forming from one to several eggs in the oogonium. A fertilization tube is formed, admitting one male nucleus to each egg. The male nucleus goes to the coenocentrum and lies by the female nucleus for a considerable time and then fuses. Food is stored in the egg in the form of oil droplets. A thick wall is slowly built up about the egg. After a resting period of about three months, germination was once induced in about twelve hours by centrifuging. Several other similar experiments failed to bring about this result. Uncentrifuged eggs germinated normally in about three and a half months.

Hemp seeds and weak peptone solutions furnished the cultural media.

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EXPLANATION OF FIGURES

Camera lucida drawings were made with the 1.9 mm. objective and the 10×, 15×, and 25× oculars. Sections figured are 4 or 5 microns (μ) in thickness. The nuclei are placed in the position and number as they were in the whole section; and the protoplasm was drawn in free-hand, representing as closely as possible its appearance in median optical section. Material grown on hemp seed and in peptone solutions were both drawn, the cultural media and magnification being given after each figure except figures 17 and 25–35, which are free-hand drawings.

PLATE 8

Fig. 1. Oogonial initial, peptone culture. × 923.

Fig. 2. Median section showing mitosis in the antheridium and oogonium. Primary nuclei represented by large dots. Hemp seed culture. × 1170.

Fig. 3. Tangential section of a different oogonium from fig. 2, showing mitosis in both organs. The central vacuole is present, but is not reached in the section. There is only one nucleus in the antheridium, and about 12 in the oogonium. The oogonial wall seems very thick because cut at an angle. The true thickness is shown in fig. 4. Hemp seed culture. × 1170.

Fig. 4. Longitudinal section through an oogonium and an antheridium. Mitosis is complete and the daughter nuclei have rounded up. Degenerating nuclei may be faintly seen. Peptone culture. × 1170.

PLATE 9

Fig. 5. Tangential section of a median peripheral stage in a very large oogonium. Primary nuclei are recognizable only by their chromatin granules. Section being off center shows wall too thick. Very irregular inner surface of wall due to crumpling and cracking difficult to show properly in the figure. Hemp seed culture. × 795.

Fig. 6. Late peripheral stage in a very small oogonium. Only one survival nucleus is present; degenerating secondary nuclei are shown faintly outlined; primary nuclei are now mere dots. Peptone culture. × 923.

Fig. 7. Late peripheral stage showing pore forming beneath the antheridium. Peptone culture. × 923.

Fig. 8. Late peripheral stage showing one nucleus in the antheridium, a parietal row of degenerating secondary nuclei in the oogonium, and smaller primary nuclei in various stages of degeneration. Peptone culture. × 923.

Fig. 9. Balling stage; the nucleus is associated with the coenocentrum, around which the protoplasm is balling up. The nucleus of the other egg-initial is seen in the next section. Only two oospheres will be formed. Peptone culture. × 923.

Fig. 10. Oosphere completely rounded up; the female nucleus associated with the coenocentrum. The fertilization tube is not yet formed. The egg is surrounded by a very delicate membrane. There has been no shrinkage. Hemp seed culture. × 1170.

Fig. 11. Fertilization tube partially formed; only a segment of the oosphere shown. The lower portion of the oogonial wall is broken away. In this figure and in the next, certain displacements in sectioning have thrown the antheridium somewhat out of its natural position. The smallest part of the antheridial tube shown is the real place it should enter the oogonium. In fig. 11, the tip of the antheridial tube was probably in contact with the egg. Hemp seed culture. × 945.

Fig. 12. Fertilization tube fully developed and in contact with the oosphere; the male nucleus is in the tube, female nucleus at the center of the egg. Peptone culture. × 945.

PLATE 10

Fig. 13. Tip of the fertilization tube in contact with the oosphere. Male nucleus almost entering the oosphere. The female nucleus is at the center of oosphere and is not shown. Peptone culture. × 923.

Fig. 14. Male nucleus just after its entrance into the oosphere. Pore in the fertilization tube apparently still open. Hemp seed culture. × 945.

Fig. 15. A branching fertilization tube after the male nucleus has entered the oosphere. The tube is beginning to collapse. The actual entry was almost certainly made from the upper branch. Hemp seed culture. × 923.

Fig. 16. Oosphere showing male nucleus migrating toward the coenocentrum. It has enlarged considerably. A delicate membrane has formed about the egg, as is shown by a single line from which the egg has shrunk away. Hemp seed culture. × 1800.

Fig. 17. Free hand drawing of male and female nuclei after the male has migrated to the female. The coenocentrum here is much reduced.

Fig. 18. Male and female nuclei are together and are embedded in a small coenocentrum. Degenerating primary and secondary nuclei are yet visible. Egg membrane shown partly broken above. Peptone culture. × 1170.

Fig. 19. Oospore partially matured. The egg wall has thickened but not reached full thickness. The male and female nuclei have not yet fused. Hemp seed culture. × 1170.

PLATE 8

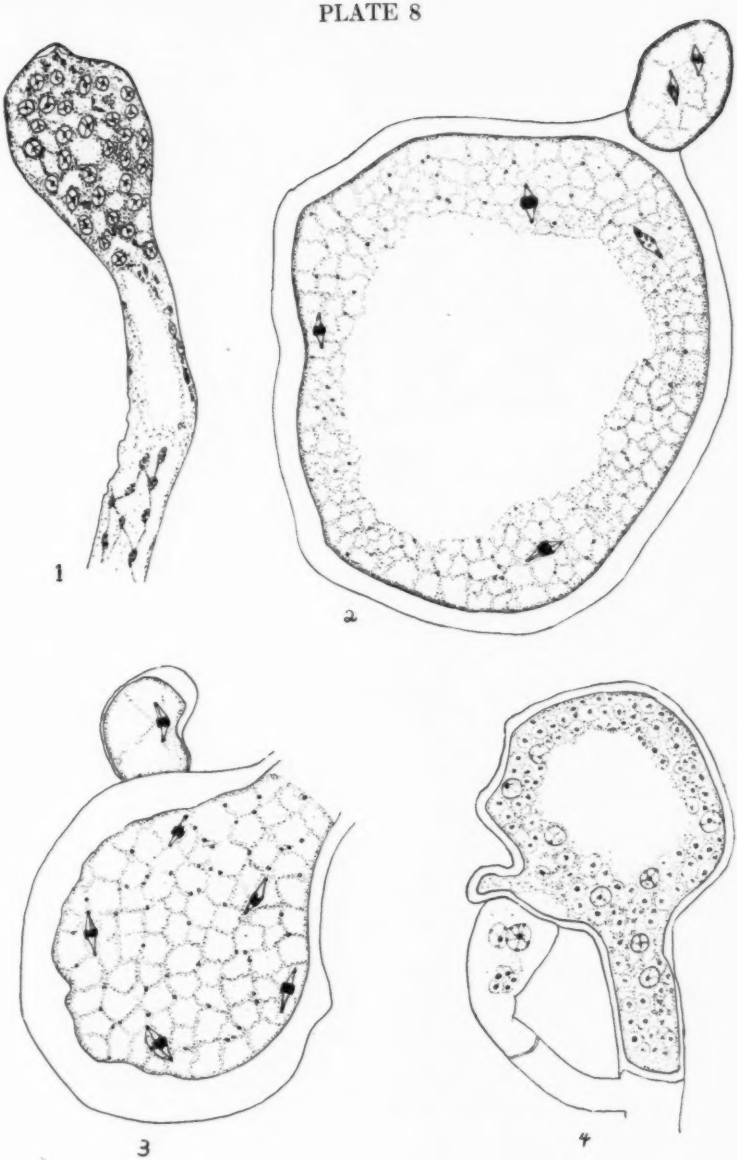

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PLATE 9

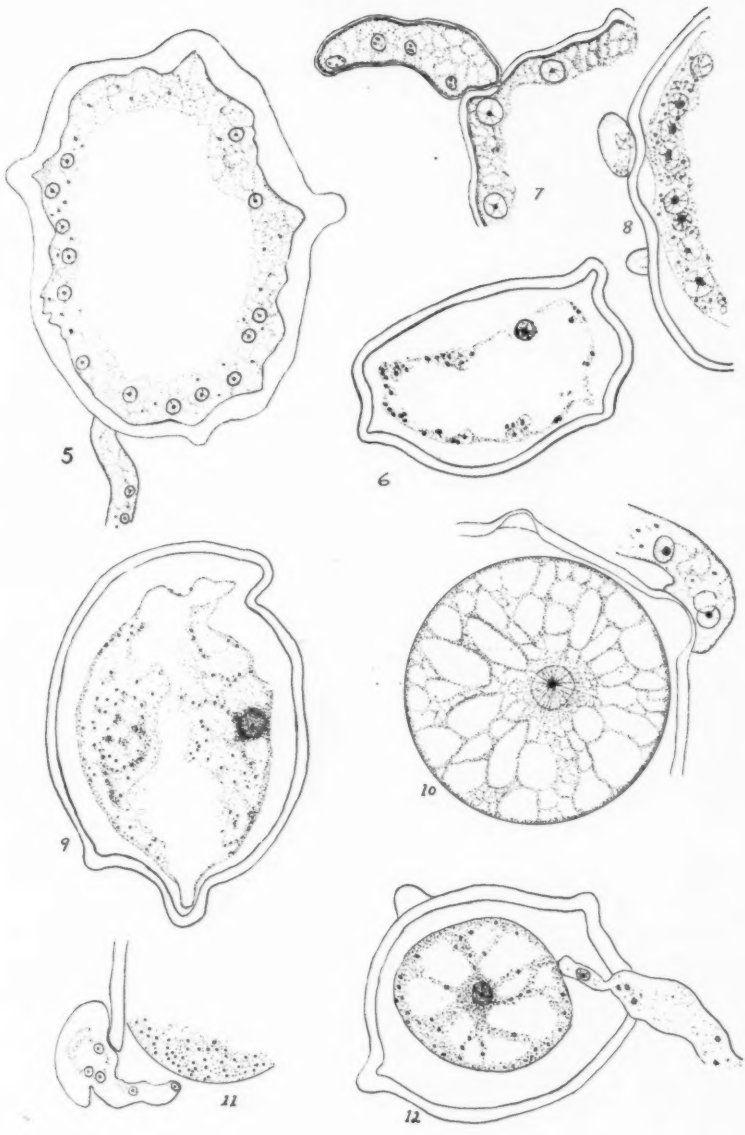

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PLATE 10

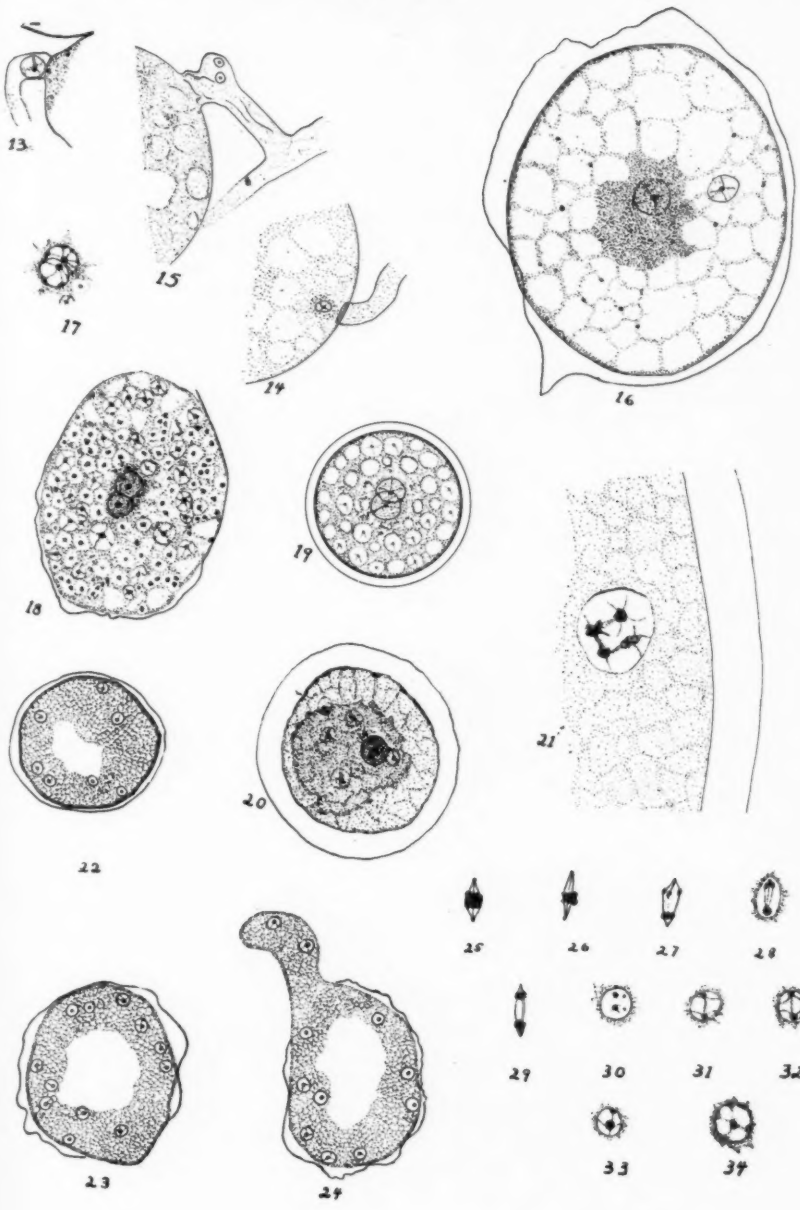

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Fig. 20. Old oospore with nuclei fused. Degenerating nuclei still faintly visible. Egg wall has now reached full thickness. Peptone culture. × 1170.
Fig. 21. Peculiar appearance in mitosis in median peripheral stage of the oogonium. Hemp seed culture. × 3165.
Fig. 22. Germinating egg in the 32-nuclear stage. × 923.
Fig. 23. Germinating egg: commencement of the germ tube, 32-nuclear stage. × 923.
Fig. 24. Germinating egg: tube well formed, 64-nuclear stage. × 923.
Figs. 25–34 show mitoses in peripheral protoplasm of the oogonium. Free hand drawings.
Figs. 25, 26. Late prophase.
Fig. 27. Early anaphase.
Fig. 28. Late anaphase and the commencement of telophase.
Fig. 29. Telophase.
Fig. 30. The nuclear membrane has appeared: two large and two small chromatic aggregates are present. The linin fibers are beginning to appear.
Fig. 31. More advanced stages than the last, centrosomes are invisible.
Fig. 32. Same, with an extra granule visible.
Fig. 33. A daughter nucleus with two distinct chromatic bodies.
Fig. 34. A typical resting secondary nucleus.

OOGENESIS IN PYTHIUM TORULOSUM

By Paul Morrison Patterson

Plate 11

Historical

In June, 1901, Trow published in the Annals of Botany his observations on *Pythium ultimum*. In this species described by him as new, the antheridium and oogonium are both multinucleate; after a septum has cut off each as a separate organ, and the ooplasm and periplasm have begun to be differentiated, the nuclei form a ring at the periphery of the ooplasm, except one which remains at the center. Simultaneous division involves all the nuclei in both organs, and all but the functional nuclei in both organs disintegrate. The fertilization tube penetrated the ooplasm and admits one nucleus which does not fuse for some time. The mature egg is uninucleate, with a thick wall and much reserve material.

Miyake published in the same journal, in December of the same year his observations on *Pythium de Baryanum*. His account is similar to Trow's except that there is no nucleus in the center of the peripherally arranged nuclei just before division, but the functional one migrates in after division; and that the ooplasm and periplasm are not differentiated until after the nuclear division.

Edson in 1915, worked out the oogenesis of *Rheosporangium aphanidermatus*, which has later been placed in the genus *Pythium* by Fitzpatrick ('23). This species is remarkable for having the division of the nuclei occurring before their entry into the initials of the organs, for the appearance of a central vacuole in the ooplasm, and for the multinucleate resting egg.

Material and Methods

Pythium torulosum was found in Chapel Hill, and a description of the mold may be found in the May issue of this Journal. A one spore culture free from bacteria, growing on maltose peptone agar, was transferred in small blocks to autoclaved halves of hemp-seeds in sterilized

petri dishes, and floated in autoclaved distilled water. Oogonia of all ages and sporangia were produced in abundance. The material was killed by drawing off the water and filling the petri dishes with an aqueous solution of 0.5 per cent acetic and 0.3 per cent chromic acids. The chromo-acetic acid was allowed to act for 36 hours, and then the material was washed for 24 hours. The hemp seed was removed and the mycelium balled up in melted 1 per cent agar previously melted and allowed to cool almost to the point of gelatinization. These balls of mycelia were passed through a very gradual series of alcohols, xylols, and gradually to 62°C paraffiine. Sections 4 and 5 microns thick were cut, and the sections stained on the slide with Haidenhain's haematoxylin, and Gram's strain and Orange G. in clove oil. Both of the stains were good, although most of the observations were made from material stained with Gram's stain.

DEVELOPMENT OF THE ANTHERIDIUM AND OOGONIUM

The oogonium is formed mostly as a lateral growth on a short stalk. Antheridia are androgynous and grow from the oogonial stalk or from the hypha near the stalk. Dense protoplasm packs into the oogonium carrying about 5–10 nuclei with it, (fig. 1). These are much elongated in the direction of protoplasmic flow as they enter the oogonium, but soon round up into resting nuclei. Once the nuclei were seen in metaphase as they were entering the oogonial initial. Twice, division of the nuclei in the oogonium was seen after the formation of the ooplasm, and appearance of the coenocentrum (fig. 3). There are one or two antheridia to each oogonium. The antheridia are slender tubes usually with an enlarged tip. The protoplasm does not pack as densely into the antheridia as into the oogonia, and it carries in only from 1–4 nuclei into each. The nuclei in the initials of the sex organs undergo a simultaneous indirect division. Just before this process they are arranged in a hollow sphere in the oogonium with one nucleus in the center, as noted by Trow for *Pythium ultimum*.

The resting nucleus is similar to those of the *Saprolegniaceae*, consisting of a central chromatin mass, from which radiate a few linin strands to the nuclear membrane. In division, an elongated spindle is formed with only two spindle fibers visible. At each end of the spindle is a deeply staining spot, here considered the centrosomes. The chromosomes are short thick rods. A count of the chromosomes was clearly made upon six different nuclei, and in each case, there were apparently two chromosomes. The nuclear membrane disappears

with the formation of the spindle and returns again in late anaphase. The chromosomes, after reaching the centrosomes, round up into "nucleoli," and the nucleus quickly constricts into two daughter nuclei.

When the daughter nuclei have rounded up, all but the functional nucleus in each organ soon start to degenerate. Cross-walls cut off the oogonia and antheridia, and ooplasm and periplasm quickly become differentiated. Several times, an abnormal condition was seen where two oospheres were formed within a single oogonium (fig. 11), though no such condition was seen in maturity. The degenerating nuclei, due to their peripheral arrangement, come to lie in the periplasm, at the edge of the ooplasm (fig. 5). The periplasm is extremely delicate and in a very few cases was its vacuolate protoplasmic structure demonstrable (fig. 9). It is also very thin (1–3μ), often scarcely visible. Degeneration of the supernumerary nuclei is usually rapid and soon there is no, or scarcely any, trace of them left. At times, however, they may persist until the commencement of the maturation of the oospore. In the case of the centrally dividing nucleus in the oogonium, one persists as the functional female nucleus, while the other degenerates. Trow thinks that the degenerating one in *P. ultimum* passes to the periphery and degenerates there. In *P. torulosum*, there is seen in the mature egg, in sharp contrast to the clearly defined, deeply staining egg nucleus, another nucleus about the same size, but exceedingly faint, though all of the characteristic nuclear structures are present (fig. 12). This nucleus is supposedly the degenerating member of the pair of nuclei originating from the division of the centrally arranged nucleus of the oogonial initial. Its intervening history has not been traced due to the obscurity of the nuclei during the vacuolate stage of the ooplasm.

Shortly before fertilization, the ooplasm becomes coarsely vacuolate by the anastomosing of enlarging vacuoles. This continues in many cases until a large central vacuole is formed, occupying a large part of the space of the ooplasm (fig. 7). Apparently, this vacuole is sometimes never formed, and the ooplasm remains for a short time in a spongy state, consisting of a few large vacuoles. Fertilization sometimes occurs at the time of the central vacuole (fig. 9), though usually the vacuole is on the wane or has become entirely obliterated.

A coenocentrum may appear before vacuolization begins (fig. 3), though it usually appears during vacuolization or after. The female nucleus is found in it though the whole body stains so deeply that the nucleus often is not observed. The male nucleus when admitted mi-

grates to the coenocentrum and quickly fuses with the female nucleus there. A coenocentrum did not occur in the materials studied by Trow and Miyake.

A fertilization tube is formed in the antheridium during some phase of the vacuolate stage of the oogonium. The antheridium now contains only one functional nucleus, the rest having degenerated. The tube admits the male nucleus when it reaches the ooplasm (fig. 9). Sometimes when the antheridium is closely appressed to the oogonium no well defined tube is formed, especially when the periplasm is very thin, there being merely a slight protuberance from the antheridium.

MATURATION OF THE OOSPORE

The coenocentrum remains for a short time with the fused nucleus imbedded within it, but soon disappears as food material begins to be deposited. A wall appears about the ooplasm shortly after fertilization, and thickens at a uniform rate until a wall 0.8–1.5μ thick is built up. The periplasm with the residue from the degenerating nuclei probably helps in building up the egg wall, as no trace of it is visible on the outside of the mature egg. The ooplasm builds the wall up from the inside, and stores up a great deal of food in the center of the egg. The food may be in scattered globules or in several irregular blocks, or in one large spherical mass in the center of the egg. Sometimes the food material makes its appearance before the egg wall thickens appreciably, but usually later. The egg nucleus is large, and takes stain deeply, and is usually not so crowded between the food material and egg wall as to lose its spherical shape. The mature egg completely fills the oogonium, or practically so. Germination of the eggs was not observed.

This work was done at the University of North Carolina, at the suggestion and under the supervision of Dr. W. C. Coker, for whose criticism and encouragement the writer wishes to express his hearty appreciation.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

LITERATURE

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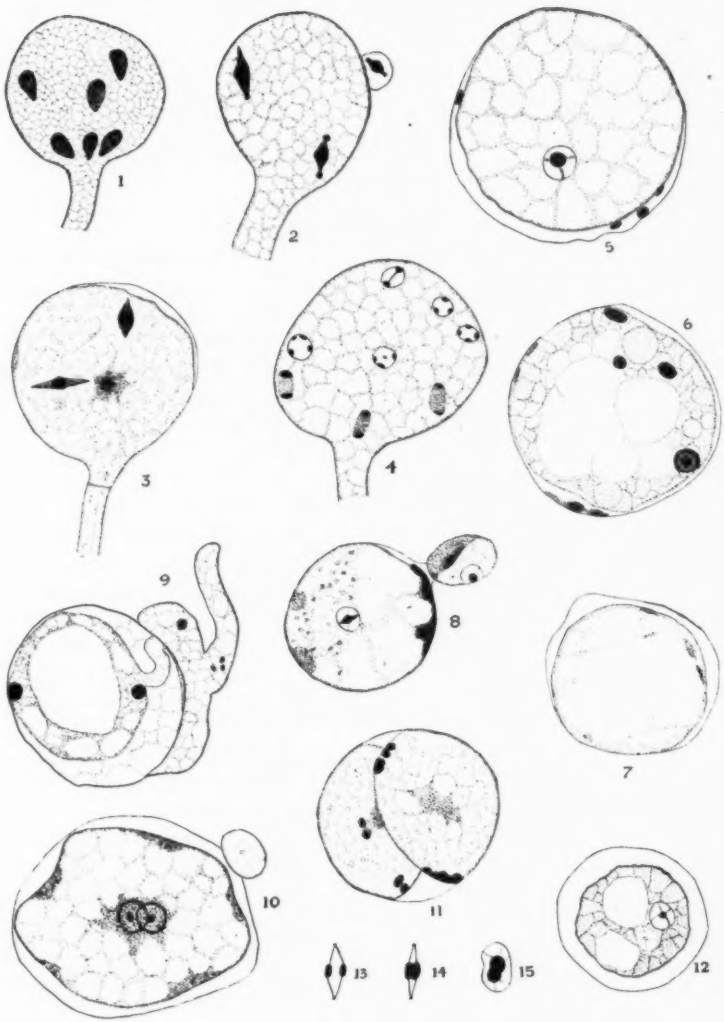
EXPLANATION OF PLATE 11

All figures except 13–15 are from camera lucida drawings, but the protoplasm was filled in by free hand.

Fig. 1. Oogonial initial with the nuclei entering. × 2814.
Fig. 2. Division of nuclei in the antheridium and oogonium. × 2814.
Fig. 3. A case of delayed nuclear division in the oogonium; the periplasm is forming and the coenocentrum has appeared. × 2134.
Fig. 4. Oogonium with 3 nuclei in telophase and 5 daughter nuclei rounded up. × 2814.
Fig. 5. Periplasm and ooplasm differentiated. Supernumerary nuclei degenerating and the functional nucleus obvious. × 2814.
Fig. 6. Large central vacuole in process of formation. × 2814.
Fig. 7. Exceptionally large central vacuole. × 2134.
Fig. 8. Antheridium and oogonium just before fertilization. × 2134.
Fig. 9. Fertilization. × 2814.
Fig. 10. Male and female nuclei in coenocentrum. × 2814.
Fig. 11. An abnormal case: two oospheres in one oogonium. × 2134.
Fig. 12. Mature egg with nucleus and reserve food; a faint degenerating nucleus apparently present also. × 2134.
Figs. 13–15. Stages in nuclear division.

PLATE 11



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NEW OR NOTEWORTHY BASIDIOMYCETES

By W. C. Coker

Plates 12–22

Sarcodon fumosus Banker

Plate 21

Cap 8.5–9.8 cm. broad, convex with the margin somewhat irregular and lobed, surface softly felted-tomentose, grayish tan, darkening to drab with a purplish tint in the center. Flesh 1.5 cm. thick at stem, gradually thinning toward margin, quickly turning to purplish drab when cut, strongly olivaceous when dry; taste bitterish, odor rather pleasant, aromatic woody.

Teeth pallid grayish white when quite fresh, staining blackish brown when bruised, rather delicate, irregular in length, up to 5 mm. long, tips turning strongly greenish on drying.

Stem 2–2.8 cm. thick, 5.5–6 cm. long, enlarged at the base, pallid grayish tan, rapidly darkening to blackish brown on being handled.

Spores light brown, coarsely tuberculate, irregularly oval in outline, 7–8.5 x 9–11.5μ.

This is the first record of this plant since its discovery by Murrill in the mountains of North Carolina, and we are adding certain information on the characters of the fresh plant, such as odor, color and color changes. Our plants are much larger than the types, but as all other characters are the same, we think they should for the present be referred to this species. Banker does not mention that the dried teeth (as well as the flesh) of *fumosus* have an olivaceous tint, but this is clearly shown by the type, though the color is darker than in our plants. This could easily be an accident of drying. The species is one of the most elegant and sharply marked of Hydnums. We got a good photograph of this plant in the fresh condition, but unfortunately it was ruined in developing.

North Carolina. Chapel Hill. In mixed woods, July 25, 1927. H. R. Totten, coll. (U. N. C. Herb. No. 8193).

Sarcodon Murrillii Banker[1]

Plates 12 and 22

Last summer (1926) we were fortunate to find in the mountains of this state two ample colonies of this species, and we can now add notes on the fresh condition which have heretofore been lacking. The plant has been known before with certainty only from the type collection from Transylvania County, N. C. Banker says that some of the plants distributed in Ellis's North American Fungi as *H. imbricatum* are this species.

Our description follows:

Plants up to 9.5 cm. broad, expanded with depressed center and usually drooping margin which in youth is white and inturned. Surface coarsely to moderately scaly, clay color when young, then brown with the clay color remaining more permanent between the scales. Flesh up to about one cm. thick, pale brown, sometimes faintly purplish above; taste sweetish and slightly to very distinctly and rankly farinaceous bitter, apparently most bitter in age; odor sweetish, pleasant.

Teeth very pale when young, passing through pallid fawn to brown, tips whitish until old, very short, 0.5–1.7 mm., decurrent, sharp pointed.

Stem crooked and irregular, about 5.5–7 cm. long and 9–15 mm. thick, color of cap below, paler above, base usually bent and pinched to a more or less sharp point; when quite fresh covered at the base with pure white mycelium, internally more or less cavernous, brownish, the base blackish olive; surface below also blackish olive after being handled. All parts of the plant may become faintly tinted with purple when soaked or old.

Spores subspherical to irregular, angled and bluntly warted, 4.8–6.8μ.

From this description it will be seen that the only sharp distinction between this species and *H. fennicum* is the very much shorter teeth of the former. The teeth are shorter than in any other fleshy stipitate *Hydnum* we have seen. Those of *Underwoodii* are next shortest (up to 2 mm.). That is easily distinguished by colorless base and smoother and paler caps and milder taste. The taste of *H. Murrillii* seems to vary with age and freshness. When first collected the plant tasted was

[1]This plant and all others mentioned below from the mountains of North Carolina, except where indicated, were collected in the summer of 1926 by the following members of the botanical staff and students at the University of North Carolina: W. C. Coker, H. R. Totten, Alma Holland, H. H. Braxton, Velma Matthews, and Adrian Couch.

only mildly bitter, but the next morning it and others were harshly bitter, almost as in *H. fennicum*.

North Carolina. Haywood County. Along Crawford Creek, July 26, 1926. (U. N. C. Herb.).

Phellodon Ellisianus Banker

We have found this rare little species again, making the third record of its occurrence. It was growing in humus in damp mixed woods at Linville Falls, N. C., elevation about 3200 ft. The plants are just like those from Chapel Hill reported in our first *Hydnum* paper in the Elisha Mitchell Journal **34:** 163. 1919.—(U. N. C. Herb. No. 8203, Sept. 9, 1927; Coker, coll.)

Polyporus umbellatus Fr.

Plate 13

Plants highly compound, 13–27 cm. broad, branching repeatedly with terete stalks from a massive base about 2–7.8 cm. thick which tapers to a blunt rooting point. Stalks separating from each other at a strong angle and then ascending. Individual caps about 4–9 cm. broad, some of the lower ones smaller, irregular, stalks usually eccentric to subcentric, rarely almost lateral; center deeply depressed, shape irregularly infundibuliform, margin much lobed and crenated; surface glabrous whitish straw color when young, turning brownish straw color and very soon heavily speckled with dark brown dots. Flesh whitish, about 2–5 mm. thick, soft and very fragile, fibrous; taste slight, odor strong, almost exactly that of a laundry.

Tubes large, irregular, about 2–3 to a mm. and 2 mm. or less long, mouths uneven, more or less lacerate, strongly decurrent, pallid white when young, becoming dull yellowish.

This is evidently *P. umbellatus* or an undescribed species, as that is the only known species with this habit (large, highly complex, with distinct, divergent, terete stalks and capitate, umbilicate pilei). The caps of our plants are much larger than described for *umbellatus* (1–4, rarely 5 cm.). The caps are usually described as fibrillose or pruinose or villose, but dried specimens we have seen (New York and Michigan) have glabrous caps as in ours. The spotted caps and no obvious attachment to stumps may be accidental and of no importance. The unfortunate absence of spores in our plants makes it impossible for us

to be quite certain of its identity with *umbellatus*. The spores of a plant from Ann Arbor, Michigan, kindly sent us by Dr. Kauffman, are smooth, elliptic, 3–3.7 x 8–9.5μ. The fruit body is said to arise from a complicated sclerotium.

Of all the species of *Polyporus* we know, this is by far the most fragile and ephemeral. When found (there were two plants, nearly touching, but from different bases) they were apparently in good condition above, but the roots were already blackish and rotting, and the fertile part was being attacked by a multitude of minute grubs which had entirely eaten away the hymenium, so that no basidia or even spores were to be found. A slimy mass near by showed where another cluster had recently decayed. The plant appears more fragile than and at least as ephemeral as a delicate *Boletus*. In America the species has never been reported south of Ohio.

North Carolina. Chapel Hill. On a muddy bank in swampy woods, Emerson farm, June 26, 1927. (U. N. C. Herb. No. 8174).

Polyporus holocyaneus Atk.

Plate 22

Cap about 1.8 cm. broad, convex, soon nearly plane, margin strongly incurved permanently. Surface viscid, glabrous, but pitted and lined with slight elevations. Color dull bluish slate, when young blue of a brighter tint. Flesh pallid, delicate, gradually thickening to the stem where it is about 3 mm. Practically odorless and tasteless. Tubes very short, about 1/3 mm., angular, small, about 4 or 5 to the mm., strongly decurrent half-way or more down the stem.

Stem crooked, about 2.5–3 cm. long, 3–4.5 mm. thick, glabrous, color of cap, white at base, mycelium white and stringy. Flesh solid like that of cap. Both cap and stem soon riddled by little grubs.

Spores smooth, hyaline under microscope, 3–3.7 $\times$ 3.7–4.5 μ.

In youth margin is pale and delicately granular, the granules passing into the peculiar more or less rugose lines on the cap surface.

Known heretofore only from the type, found at Blowing Rock, N. C., by Atkinson in September, 1901. Our plants are smaller than the type, but evidently the same.

North Carolina: Linville Falls. On ground, damp bank, hemlock, rhododendron woods; altitude about 3000 feet, Sept. 9, 1927. W. C. Coker, coll. (U. N. C. Herb. No. 8202).

Ganoderma ohiensis (Berk.) n. comb. and **Fomes scutellatus** (Schw.) Cooke.

In 1881 Karsten (Rev. Myc. **5:** 17) established the genus *Ganoderma* on the basis of the shining laccate surface of the cap and stem. In 1889 Patouillard (Bull. Soc. Myc. **5:** 66) recognized the importance of the spore characters and added to the genus several species previously referred to *Fomes*, among them being *Fomes applanatus*. Since then it has been generally admitted that plants with the peculiar spores characteristic of the laccate Ganodermas are not properly placed in *Fomes*. It seems to us that all of them might be called Ganodermas, which would greatly simplify matters. The recognition of *Elfvingia* does not seem to help any, as the spores of its species, as recognized by Murrill, except for *fomentarius* which does not belong there, are like those of *Ganoderma*. Murrill's statement that the spores of *E. tornata* are abundantly and roughly echinulate is not correct, as his specimens show spores like those of other Ganodermas. The wall structure of *Ganoderma* spores has recently been correctly interpreted by Coleman (Bot. Gaz. **83:** 48. 1927). It consists of a dark hard inner wall which has spine-like projections extending into the clear outer wall almost or quite to the surface. The surface itself is always smooth. A very peculiar and characteristic feature is the truncate proximal end found in most of the mature spores after shedding, due to the collapse or breaking away of an extension of the clear outer wall beyond the inner in this region. Coleman recognized the great systematic importance of the peculiar spore structure and suggests a revision of *Fomes*, *Ganoderma* and *Elfvingia*, with this point given the importance it deserves. This suggestion we entirely agree with, and have had this opinion for many years.

In the summer of 1926 we found in the mountains of North Carolina, Haywood County, good specimens of *Fomes ohiensis*. It has not been reported before south of Ohio, but Murrill found it in Virginia (Mountain Lake, 1907). In studying our plants and Murrill's, we find the spores of the same shape and with the truncate base and very thick wall as in the typical Ganodermas, but hyaline under the microscope and without any distinction between an inner and outer part to the wall. While the clear, undifferentiated wall contrasts with other species in *Ganoderma*, the thick wall and truncate base show that it clearly belongs there, that is, unless a new genus is made for it, which does not seem at all reasonable to us now. It should be included in a separate section of *Ganoderma*.

The spores of *ohiensis* have not before been illustrated, but in 1915 Lloyd (Synopsis of the Genus *Fomes*, p. 218) recognized the peculiar position of *ohiensis* in *Fomes*, on account of its *Ganoderma*-like spores. He says that *Polyporus ochroleucus* has similar spores and should be classed with it, and it is highly probable that other species will be found to belong here. In his synopsis of the section Apus of the Genus *Polyporus*, p. 311, he describes *P. ochroleucus* and gives the spores as of the form of those of *Fomes ohiensis*, and 8 × 16 μ. He adds that *P. ochroleucus* has a strong leaning toward "*Ganodermus*" in more than one respect. From descriptions, *P. ochroleucus* is very near to *G. ohiensis*. Overholts (Ann. Mo. Bot. Gard. **2**: 667. 1915) also gives correctly the spore shape of this species as that of a *Ganoderma*, but neither he nor Lloyd calls attention to the differences in the wall structure. Murrill (N. Amer. Flora **9**: 96) makes the strange statement for *ohiensis* that the spores are globose and 5 μ thick and conidia ovoid, smooth, hyaline, 7–8 × 12–13 μ. These last are evidently the basidiospores.

We are giving below our descriptions of both these species, as we have also found *scutellatus* here in Chapel Hill.

Ganoderma ohiensis

Plates 14 and 22

Sessile, sometimes attached by the top, convex or ungulate, perennial, small, about 4–10 mm. thick, up to about 2.5 cm. broad and in old plants extending as much as 4 cm. Surface chalky white when very young, soon becoming wood brown and then darker blackish brown, at first dull and with somewhat the texture of chamois, soon becoming glabrous and at times almost shining, sulcate-zonate. Flesh at first white, becoming brownish, very tough, about 2–4 mm. thick.

Tubes indistinctly layered in older parts, each annual layer about 2 mm. thick or less, mouths minute, 4 or 5 to a mm., the walls as thick as the openings, internally about the color of the flesh, the mouths remaining white for a long time, dark brown in age.

Spores pale under the microscope, smooth, gourd seed shaped, wall thick but not compound or pitted except for one pit at the proximal end extending nearly to the point of attachment (hard to see), 7.4–9 × 10–13 μ.

Aside from the conspicuous difference in the spores, this species differs from *Fomes scutellatus* in typically dimidiate and not scuttelate

habit, larger size, thicker body, and pure white mouths of the tubes which are unchanging except in old age. *Fomes scutellatus* also differs in the prevailing cartilaginous appearance of the margin. The margin of *G. ohiensis* may not remain indefinitely white, however, as stated by some authors. Overholts also finds that the tramal threads in *ohiensis* are unbranched while in *scutellatus* they are much branched.

North Carolina. Haywood County. On deciduous wood, July 28, 1926. (U. N. C. Herb.).

Virginia. Mountain Lake. Murrill, coll. (N. Y. Bot. Gard. Herb. and U. N. C. Herb.). Spores 5.5–8 × 10–12 μ.

Fomes scutellatus

Plants small, about 1–1.5 cm. in longest direction or much smaller, typically dorsally attached on the underside of dead branches (said to be sometimes shelving), irregular, concave below with deflexed margin; surface zonate, dark brown to blackish, nearly or quite glabrous, margin whitish when growing, becoming cartilage brown or darker. Context tough, corky when fresh, woody when dry, in our specimens about one mm. thick. Tubes about one mm. long, mouths very minute, about 6 to a mm., rounded with thick dissepiments, whitish at first but soon discolored to pallid tan or whitish over cartilage color.

Overholts (l.c.) for the first time found and described the spores of this species ("cylindric, hyaline, smooth, 8–9 × 2.5–3.5"). He calls attention "to the fact that they are like those of a *Trametes*" but he prefers to retain the species in *Fomes* because of its perennial habit. It is obvious to me that this and *ohiensis* are not closely related as usually supposed, but belong in different genera.

North Carolina. Chapel Hill. On under-side of a corticated hickory limb on the ground, Jan. 25, 1920. (U. N. C. Herb. No. 4030). Spores not found.

Poria Cocos (Schw.) Wolf.

Plates 15–16

In May of this year there was brought to us by one of our botanical students several tuckahoes that were growing on the roots of cedar. They had been plowed up by Mr. Luther Williams at Stovall, Granville County, N. C., near the edge of a field. One of these was by far

the largest ever reported, with a weight when it reached us of 22¾ lbs. About a pound had been torn away in unearthing it. The photograph shows this specimen greatly reduced. Wolf reports the largest plant seen by him on pine roots as about 7 lbs. and the largest on corn as 4½ lbs. Fries says they get to be about the size of a man's head. This is also the first time the plant has been recorded on cedar. With this large plant there came also a smaller and apparently younger compound-looking, much elongated specimen on a large cedar root. This had developed at three places into 3 tuckahoe lobes connected by much thinner issue of the fungus. These lobes were developed on one side of the root, but the thin invading tissue, that is, apparently parasitic tissue, extended as a thin film entirely around the root between the wood and the bark and extended some distance each way along the root beyond the protuberances. Even under the protuberances the wood showed no signs at all of invasion and looked exactly as in a normal root. In this region the wood was about 2–2.8 cm. thick. At some distance from the nodules the parasitic layer under the bark was less than a millimeter thick, but in the immediate neighborhood of these growths it gradually became thicker. From material on hand it is obvious that the fungus invaded live roots, confining itself to the soft inner bark and running extensively in both directions for nourishment, meanwhile giving rise at one or more places along this distance to the massive sclerotic growths of the tuckahoe. In our material it would seem that while the enlargements might begin some distance apart, there would be a tendency for them to unite by a thickening of the tissue between them.

The largest plant shown in the photograph and one of the smaller ones were put under glass in an effort to get the fruiting *Poria* to form. In both cases the *Poria* began to appear in a few days. While fresh and fruiting vigorously the *Poria* surface from the large specimen was studied and found to be identical in its characters with the plant described by Wolf. Spores pure white, 3.5–5 x 7–8 μ. Basidia 4-spored, 7–8 x 21–24 μ.

It was interesting to note an additional development of this *Poria* during a growth of about three weeks. The part on the under side remained thin, as in Wolf's plant, but some way up the side where the fruiting surface stopped, the pores developed laterally exactly as in a shelving polypore except that the surface had no tramal covering but was made up of crowded pores. On the under side of these lateral growths, the pores elongated to a length of one cm., hanging straight

down as would be expected. The photograph here shown (pl. 16) gives a good idea of the appearance of these tubes.

Aleurodiscus apiculatus Burt

Plate 21

This species with very peculiar spores and paraphyses is reported in Burt's Monograph (Ann. Mo. Bot. Gard. **5**: 186. 1918) only from the West Indies (Jamaica, Porto Rico, and Grenada). We find it in the mountains of North Carolina, an addition to the flora of the American continent. Burt's description is adequate, but we are publishing herewith figures of the spores, basidia and paraphyses, as Burt's spore figures do not agree exactly with ours, having spines too large and on all sides. In our plant they are small and are lacking on the straight side. Our measurements are also larger than his. We make them 15–18 x 25–30 μ. We can also add to the description that the spores when freshly thrown in a good print are bright pink. Burt describes the spores of this genus as having a colorless wall, and in all we have seen heretofore the spores are white when fresh. This then is a peculiar exception. However, after standing in the laboratory for a year, the spores have faded to white on the print.

North Carolina. Haywood Co. On *Rhododendron* twigs, August 6, 1926. (U. N. C. Herb. No. 8051).

Cyphella spiralis n. sp.

Plate 21

Single in rather dense colonies (up to 40–50 to a sq. cm.), sometimes touching, sessile, spherical then cup-shaped, the margin incurved, very small, 0.3–0.5 mm. wide; surface about clay color (Ridg.), densely villose, the hairs about 140–150μ long, 3–4μ thick, usually rather thinly set with crystals, very peculiar in having the distal end spirally wound. Flesh very thin and delicate, scarcely more than a base for the hairs and hymenium, composed of pale yellow, rather straight, thin-walled threads about 3.5–4.5μ thick, no clamp connections seen. Hymenium pale yellow; basidia about 35μ long, 9–10μ thick with 4 or apparently sometimes only two sterigmata.

Spores subspherical, 8–9.8 x 9.5–11.3μ, with a distinct mucro.

This is easily distinct from any American species described in Burt's monograph (Ann. Mo. Bot. Gard. **1:** 357. 1914), and there is nothing like it described in European literature. From the description it seemed possibly *C. Ravenelii,* but good authentic material of that species in the New York Botanical Garden (Ravenel, No. 1709a) shows it to be easily distinct. The present plant is smaller and much more delicate, and the hairs of *C. Ravenelii* are straight at the tips. The spores are distinctly more elongated in that species. The habitat also is very different. In general appearance our plants are a good deal like *C. Sydowii* Bres., but that has straight and much longer hairs and much longer and less spherical spores. It also superficially resembles *C. obscura* Roum., as distributed in his Fungi Gall. Exs. No. 1905, but that also has straight hairs that are much thicker (5.6–7μ). That species is not mentioned in Bourdot and Galzin's Hyménomycètes de France (Bull. Soc. Myc. Fr **26:** 223. 1910), and I cannot find it mentioned in Saccardo.

North Carolina. Wilmington. On wild rose bush, November 9, 1926. C. L. Shear, coll. (U. N. C. Herb. No. 5569).

Cyphella Tsugae n. sp.

Plate 22

Plants of the shape of minute dippers standing at right angles to the bark, the concave (hymenial side) ventral, the well defined, rather thick stem lateral. Entire plant pure white, 2–3.5 mm. long; stem 0.7–2 mm. long. Cap hemispheric, about 1.5 mm. wide, its surface and that of the stem covered with minute, granular particles; margin distinctly inturned, even. Hymenial surface marked by a few, thick, low ridges of various position (see figures). Cap, including hymenium, 120–140 μ thick. Threads of flesh delicate, dotted with minute crystals. Hymenium about 25–30 μ thick. Basidia clavate, 6 $\times$ 30 μ, with two stout sterigmata. With them are somewhat more slender cells of the same height with pointed instead of club-shaped distal ends.

Spores not found.

There is nothing in Burt's monograph that approaches this except *C. capula,* and that is easily separated by the distinctly larger size, much more irregular and less dipper-like cap, even hymenium, and occurrence on herbaceous plants. From all other species it is separated by obvious characters, such as color, presence of stem, minutely granular cap, and habitat. Plants obviously spring from the bark itself and

not from the mosses in its neighborhood. It is unfortunate that no spores could be found, but other characters easily distinguish the species.

North Carolina. Haywood County. On the mossy bark of a living hemlock tree by Crawford's Creek, Aug. 2, 1926.

Craterellus albomarginatus n. sp.

Plate 22

Gregarious, single. Cap 1.3–1.5 cm. broad, deeply depressed in the center, marginal half strongly bent down or even inturned and strongly crumpled. Surface inherently fibrous and somewhat squamulous, distinctly marked all over with irregular, radiating ridges. Color when soaked deep blackish brown, not soaked, dull buffy brown. Very margin abruptly pallid. Hymenium drab gray, smooth, decurrent down a third of the stem. Flesh of cap very thin, color of surface, tough, elastic, tasteless and odorless. Stem harder.

Stem 1.5–1.8 cm. long, about 1.3 mm. thick in center, expanding and usually compressed upward, smooth and color of cap, solid.

Spores plentiful, ovate, rarely subspherical, 4.2–6 × 7–8.6 μ.

When dried the colors change but little; the cap and stem become drab; the hymenium fading to pale cinereous (dingy white).

This species cannot be referred to any North American plant described in Burt's monograph. Among the small species with somewhat similar spores, *C. dubius* is entirely too large and heavy and has a hollow stem and perforated cap; *C. delitescens* has a convex cap at first, different color and spores too large; *C. calyculus* is nearest, but that is wrongly colored in all parts and the cap shape is entirely different. In both fresh and dried condition the cap of our plant has a very characteristic form, a very broad margin drooping or inturned and conspicuously crumpled. Also the very margin is peculiar in being abruptly almost pure white. It is probable that this is the plant collected by Dr. Atkinson and referred to *C. calyculus* by Burt. The spores as given by Burt are exactly the right size for our plant, whereas the spores of *C. calyculus* are 6 × 8 μ and not just right.

North Carolina. Linville Falls. On bare earth just above the water of a spring, hemlock and rhododendron woods, altitude about 3000 ft. September 10, 1927. W. C. Coker, coll. (U. N. C. Herb. No. 8206).

Amanita Gwyniana n. sp.

Plates 17 and 22

Cap 3.5–4 cm. broad, slightly rounded, the center a little depressed, nearly white, pale creamy, margin not striate, glabrous and with no volval remnants, slightly viscid. Flesh thin, only 2.5 mm. thick toward stem, rapidly thinning to a mere membrane, white, soft, odor distinctly of chloride of lime.

Gills moderately close, white, broadly rounded at margin, 4 mm. wide, depressed around the stem and barely reaching it, with faint decurrent lines.

Stem surface smooth and glabrous, nearly pure white, up to 7 cm. long, including bulb, only about 6 mm. thick, nearly equal. Veil membranous, collapsing against the stem about 1–1.5 cm. from top. Bulb large, ovate, 1.8–2 cm. thick, margined above by a distinct lobed volva which projects up about 6–8 mm., the lobes thickish and standing free from the stem. Stem quite solid, without a stuffed center.

Spores (of No. 8149) pure white, oval, 6.5–7.4 × 9.2–11μ. Basidia about 9.2–11 μ thick, 4-spored, curved sterigmata 3.7 μ long.

This little species is obviously different from any we have seen. It looks most like a very small form of *A. verna*, but it is not that or any of its forms, the short wide gills, broadly rounded at the margin, are not at all like those of *verna*, but exactly like those of *Amanitopsis pubescens*. The spores are also more elliptic than is ever the case in *verna* and the strong odor of chloride of lime is an obvious distinction. From *virosa* and *roanokensis* with membranous volvas it differs in veil not being apical and in different spores. *Amanita virosa* as described in our *Amanita* paper agrees in absence of meal or warts and in a free volval margin, but its spores are much smaller, and the veil is apical and more friable. From *magnivelaris* it differs in being much smaller, in chlorine odor, and veil not being apical nor so fragile. *Amanita cinerea* Bres. differs in color, marginal striations, apical veil and absence of bulb. *Amanita pachysperma* Atk. (Proc. Amer. Phil. Soc. **57:** 354. 1918) differs in the same way and also in larger spores on 2-spored basidia.

We are naming this species for Mr. Lenoir Gwyn of Springdale Farm, Haywood County, who took much interest in promoting our work.

North Carolina. Haywood County. Under chestnuts, rather open woods, elevation about 3500 ft., Springdale Farm, July 27, 1926 (U. N. C. Herb. No. 8149. Type). Also on Twin Spring Mountain,

in mixed woods, July 28, 1926 (U. N. C. Herb. No. 8149a. Spores subspherical to elliptic, 6.7–9.2 × 8.3–10.8 μ).

Amanita Roanokensis n. sp.

Plate 22

Cap convex, about 8 cm. broad, spotted with thin, flat, scattered, moderately large white fragments of the membranous volva; cap surface creamy in center, nearly white toward margin, covered with a thin, removable pellicle. Flesh not fragile, odor distinct but not strong of chloride of lime.

Gills pallid, close, adnexed, moderately broad, edges conspicuously set with white granules.

Stem with a large fusiform bulb embedded in the sand; length including the bulb about 9 cm.; top of bulb marked with inconspicuous thin, short flaps of the volva pressed against the stem; stem above the volva covered with a white more or less pulverulent superficial coat like that on the gill margins; flesh solid, homogeneous. Veil ephemeral, with no obvious traces left when found, probably apically attached and like that of *strobiliformis* or *chlorinosma*.

Spores, smooth, long-elliptic, 3.7–4.5 × 10–14.8 μ.

The spore shape alone is sufficient to distinguish this species from all other Amanitas known. The plant is obviously nearest the one described by us in our *Amanita* paper (this Journal **33:** 1. 1917) as *virosa*. These two together with the species described below form a peculiar series in the *chlorinosma* group. They are distinguished from all Amanitas with chlorine odor in the presence of a membranous, somewhat toughish, not at all flocculent or friable volva. It is completely adherent to the bulb except for the very short torn flaps above.

North Carolina. Sandy soil in mixed woods near Ft. Raleigh, Roanoke Island, Sept. 17, 1927. Coker and Braxton, colls. (U. N. C. Herb. No. 8255).

Hygrophorus minutulus Pk.

Plate 21

Caps 5–9 mm. broad, umbilicate with drooping margin, slightly viscid, inherently silky fibrous, striatulate, glabrous or with the fibers broken and forming a faint scurfiness in the center, bright scarlet red when fresh, drying paler and more yellowish, then later, when fully

dry, becoming deeper, richer red. Flesh membranous, very fragile; tasteless and odorless.

Gills broad (up to 2 mm.), ventricose and thus frequently almost circular in outline, adnate and usually narrowly decurrent, waxy, creamy or yellowish or reddish.

Stem slender, about 1 mm. thick, 1.5–2.2 cm. long, stuffed, glabrous, shining, viscid, red at the top and shading to yellow at the bottom, the very base white with mycelium.

Spores white, blunt-elliptic or rarely narrowed at the proximal end, 4.8–6.5 x 8.5–12 μ. Basidia 9–10 μ thick, up to 40μ long, usually 4-spored, frequently 2-spored, and apparently at times one-spored.

This remarkable little plant seems to have been known heretofore only from the type station at Sand Lake, New York. Peck found it in grassy and mossy places in pastures, and we find it in an exactly similar situation (hillside golf course somewhat shaded by trees). The basidia seem rather peculiar. Most are typical with 4 sterigmata, but many have a central prong, looking exactly like a sterigma. However they are not certainly such, as we have not been able to find a spore on one. A case was seen in which the single prong was lateral. The plants were growing singly in a large colony of at least one hundred.

North Carolina. Chapel Hill. Among grass on golf course, August 29, 1927. (U. N. C. Herb. No. 8197).

Marasmius nigripes (Schw.) Fr.

Plates 18 and 22

This very attractive little species has not been adequately described from the living state. It was first described by Schweinitz from North Carolina (probably the middle section) and has been reported only a few times since (New Jersey, Ohio, Michigan). During the summer of 1926 we found it not at all rare in the mountains of Haywood County, N. C. The descriptions all speak of the stem as black, but as a matter of fact it behaves in a very peculiar way (see below) and the color is distinctly bluish black, so much so that the plant was known among our party as the blue-stemmed *Marasmius*. Murrill speaks of the stem as insititious, but it is distinctly not so, having an obvious little mat around the base. The very remarkable spores serve as an easy determining character.

Our description follows:

Cap 0.5–3 cm. broad, pure white, rarely with deep olivaceous stains,

hemispheric, viscid, quite smooth or at times rugulose (indicating the gills), nearly glabrous to the eye at maturity, but under the lens showing a delicate granular felting. Flesh membranous, toughish, odorless.

Gills white, distant, broadly attached, usually notched and slightly decurrent by a tooth, about 1 mm. wide, very irregular, many short and imperfect, strongly interveined.

Stem up to 2 cm. long, 1 mm. thick, covered all over with white viscid granules, the surface itself also white at first, the base soon becoming deep olivaceous blue or blackish blue, and this color rapidly extending upward so as to involve the whole or nearly the whole stem, the apex sometimes remaining white, as do the particles. When the stem is rubbed the particles come off and the stem becomes much darker. Mature stem attached by a distinct flat basal disc about 1–1.3 mm. wide and of an olivaceous brown color. This is visible in the young stages.

Spores (of No. 8154) pure white, strongly angled and spiked like jackrocks, but irregular, about 5–9.5 μ across.

The young buttons are entirely white and covered all over, cap and stem, with the viscid mealy particles. This plant is not described by Kauffman or Beardslee. The non-striate, viscid cap, broadly attached gills, and blue to blue-black stem covered with viscid white particles and seated on a dark disc are the determining characters.

Illustration. Lloyd. Myc. Notes, p. 46, figs. 19, 20.

North Carolina. Haywood County. Coker and party, colls. On deciduous leaves and twigs, July 28–August 2, 1926. (U. N. C. Herb.)

Spathularia flavida Pers.

S. clavata (Schaeff.) Sacc.

Plate 19

Plants 3.5–8.5 cm. tall and 1–1.9 cm. broad; toughish and pliable; odor and taste negligible. Stem channelled and rugose, extending up to 3 cm. into the decurrent, flattened, more or less rugose or crumpled cap which is buffy yellow, the stem glabrous, concolorous or slightly more ochraceous yellow, the base tending to reddish brown. Asci clavate, tapering strongly downward, filled with spores except for a small place at the base (much less empty space than in the case of *velutipes*) 9–13 μ thick at the broadest place, 60–135 μ long, 8-spored. Spores filiform, multiseptate, when fresh 2.9–3 $\times$ 40–48 μ, when dry shrinking in diameter to only 1.8–2 μ.

This is new to the south. It has not been reported before, apparently, south of Pennsylvania.

North Carolina. Haywood County. Growing in rings under hemlock and rhododendron, Aug. 3, 1926. (U. N. C. Herb. No. 8006). Also in rich mountain woods by Cold Creek, Aug. 8, 1926. (U. N. C. Herb. No. 8106).

Spathularia velutipes Cke. and Farlow

Plate 20

Plants 1–6 cm. high, fruiting surface buffy yellow, extending down the stem about 2 cm. Stem brown, very finely velvety or almost smooth. Odor and taste not noticeable. Asci clavate, tapering toward the base, about 11 μ thick at the broadest place, 92–111 μ long, 8-spored.

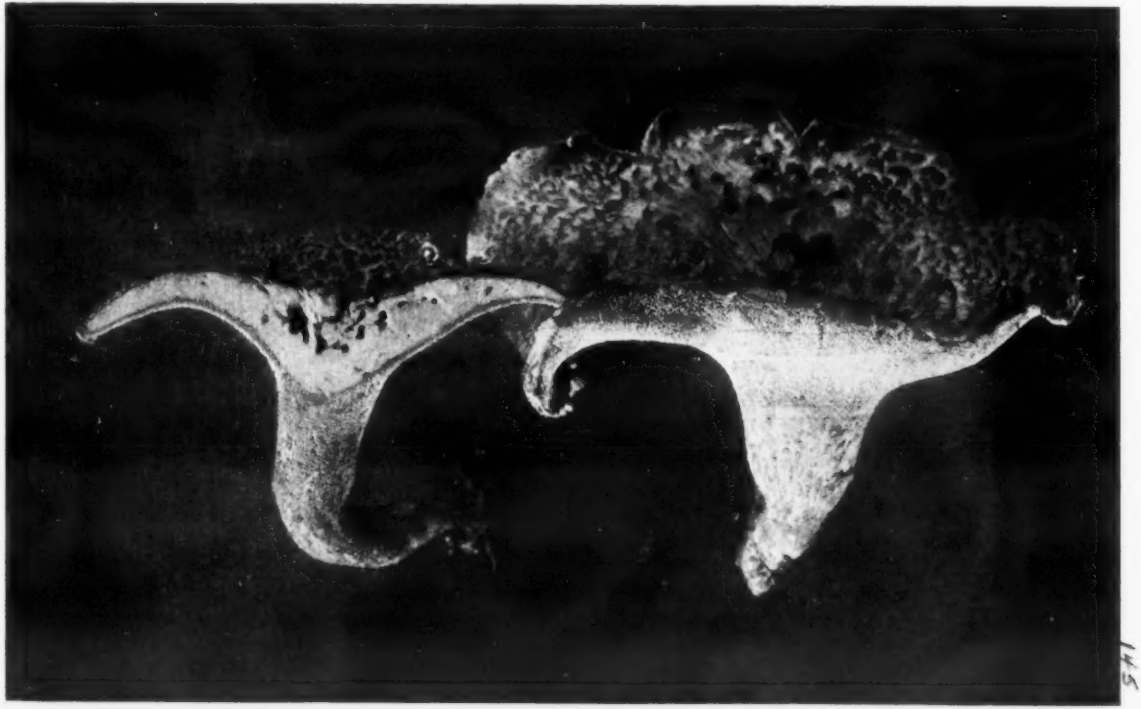
Spores multiseptate, filiform when fresh, 2.7–3 $\times$ 37–44 μ, when dry shrinking in diameter, as in *flavida*, to 1.8–2 μ.

In the field this is easily distinguished from *clavata* by the dark velvety stalk. The asci and spores are very much alike in each, but the asci in *velutipes* show much more empty space than in *flavida*. It is probable that the fresh spores have a mucilaginous sheath which shrinks in drying and is not revived in KOH. Such a sheath has been described in *S. Neesii*. In fresh specimens the color of the fertile portion is practically the same in both our species, in youth pallid, then darkening to dull yellow. Durand says (Ann. Myc. **6:** 443. 1908) that while near *rufa* of Europe this differs in the much smaller asci and spores. He does not say, however, that he has studied *rufa* himself, and Lloyd continued to think them the same (The Geoglossaceae, p. 14).

Reported from North Carolina heretofore only from Blowing Rock. (Atkinson and Schrenk, Atkinson and Durand).

North Carolina. Haywood County. By Cold Creek, Aug. 8, 1926. (U. N. C. Herb. No. 8118). Also two other collections by Crawford's Creek.

Blowing Rock. On a fir log on side of Grandfather Mountain, Aug. 18, 1922. (U. N. C. Herb. No. 5530).



SARCODON MURRILLII. No. 8028

$\frac{7}{8}$ natural size

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PLATE 13

POLYPORUS UMBELLATUS. No. 8174

Smaller of the two plants

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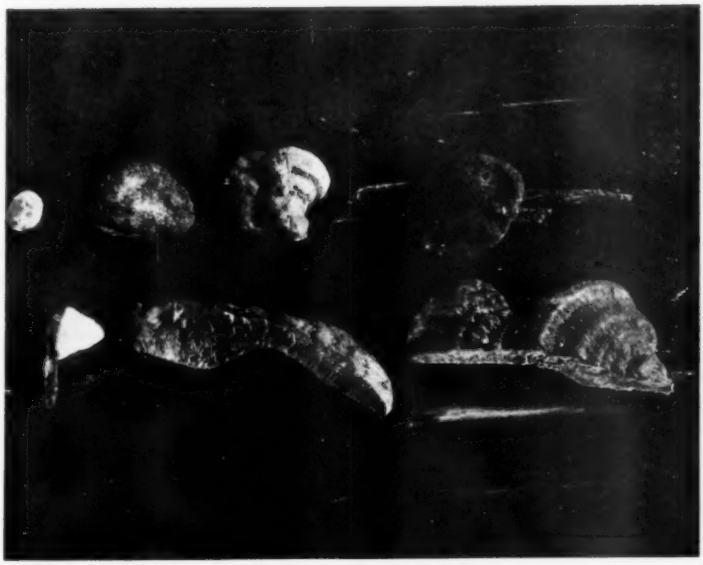
PLATE 14



GANODERMA OHIENSIS
Haywood Co., N. C.

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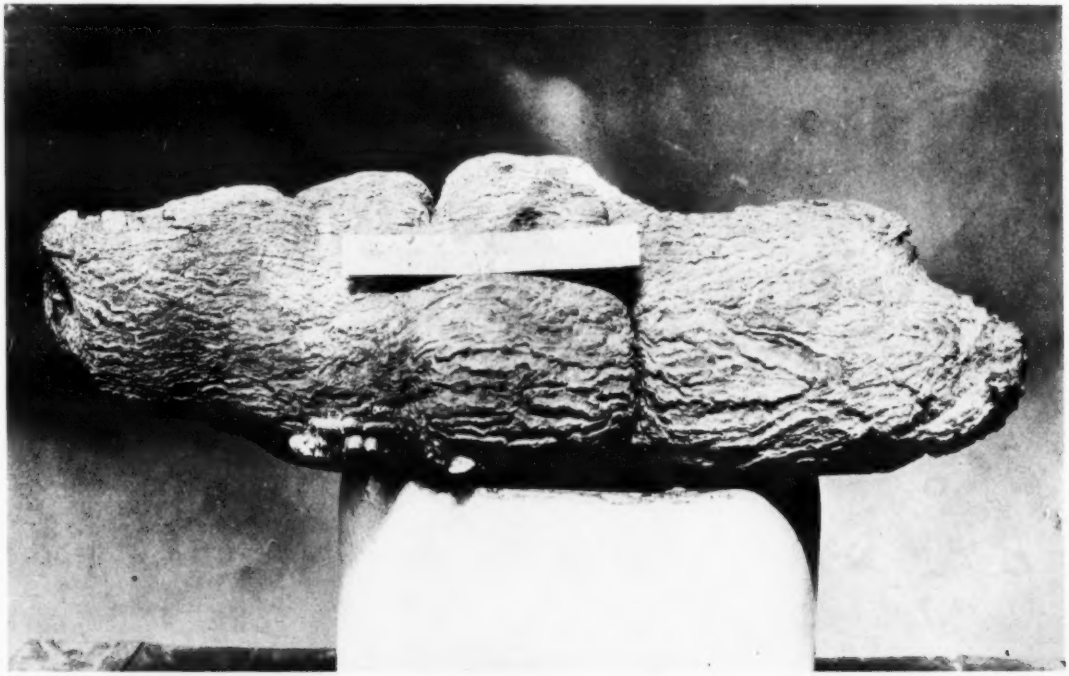
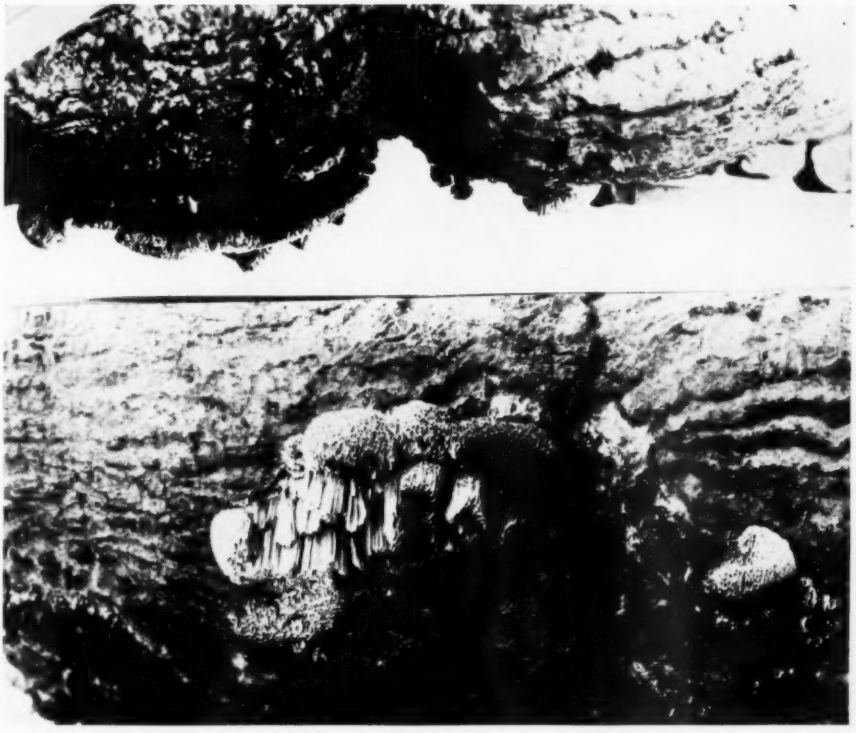
PLATE 15



PORIA COCOS. TUCKAHOE ON CEDAR ROOT, STOVALL, N. C.
Weight, 22¾ pounds

PLATE 16



PORIA COCOS

[Above] Dorsal surface of pores showing spongy structure without tramal covering.

[Below] Fruiting surface, side view. Natural size.

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AMANITA GWYNIANA. No. 8149 (TYPE)

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MARASMIUS NIGRIPES. No. 8154 (ABOVE); No. 8155 (BELOW)

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PLATE 19

SPATHULARIA FLAVIDA. No. 8006

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SPATHULARIA VELUTIPES. No. 8005

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PLATE 21

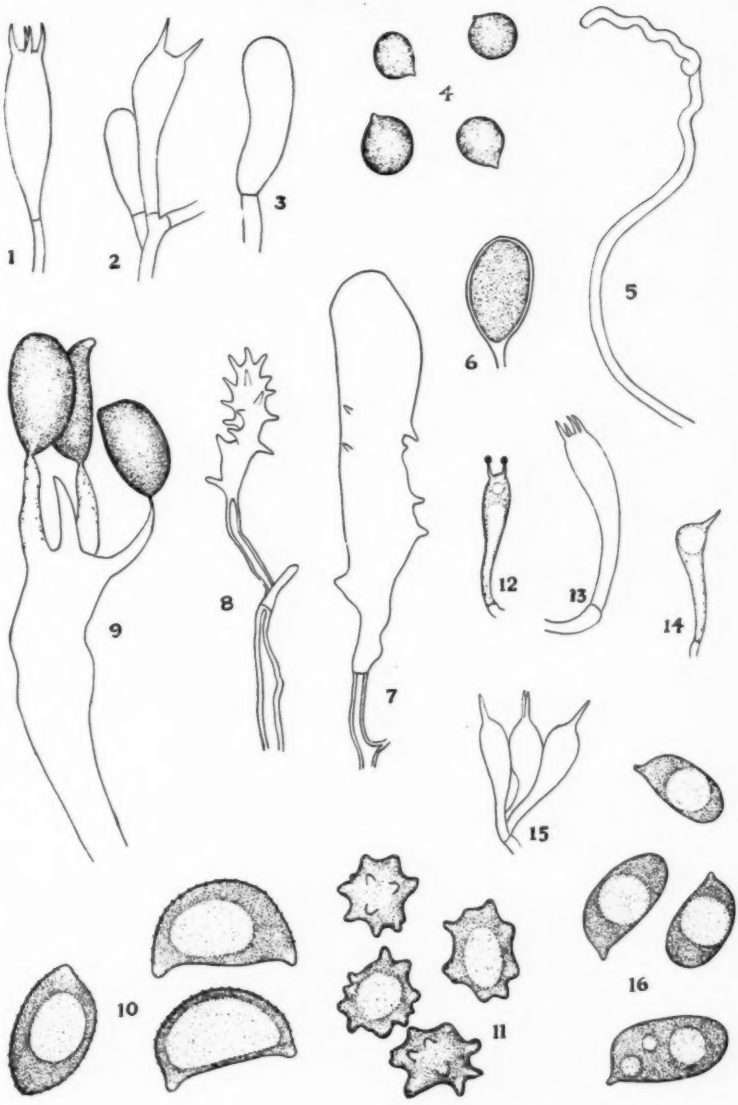

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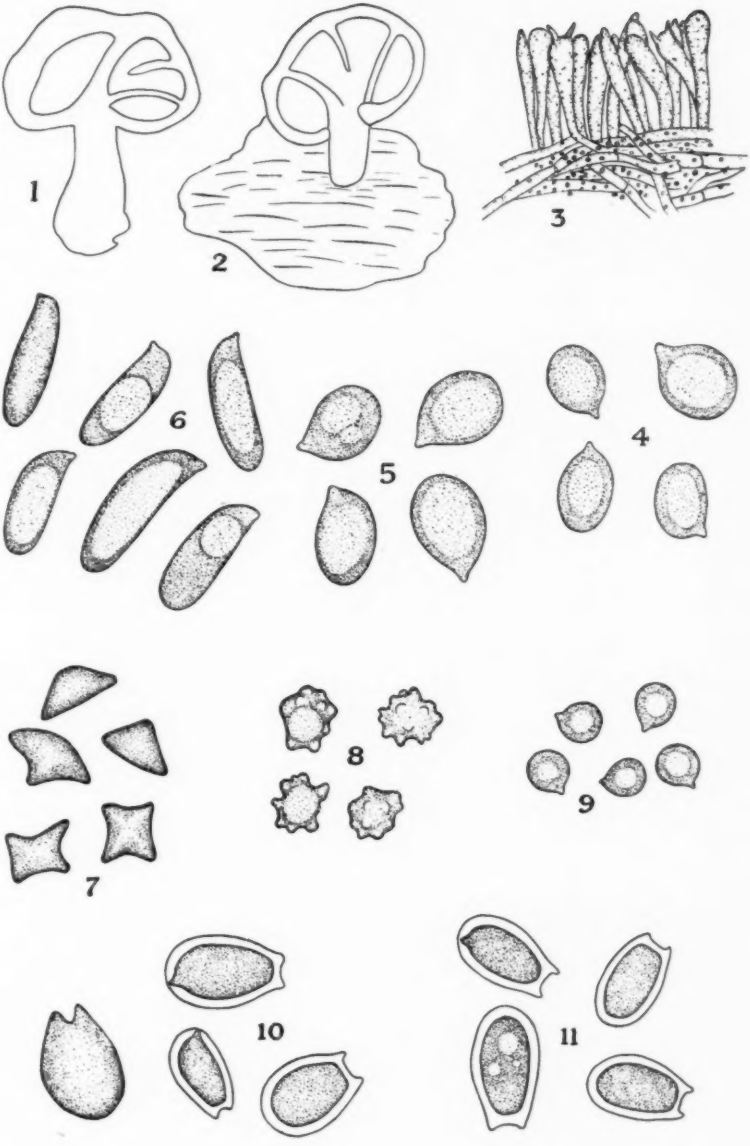
PLATE 22



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EXPLANATION OF PLATES

Plates by Alma Holland

PLATE 21

Figs. 1–5. *Cyphella spiralis*, showing basidia, sterile clubs, spores and a twisted hair from the outside of the fruit body.
Figs. 6–10. *Aleurodiscus apiculatus*, showing embedded cell, paraphyses, basidium and spores.
Fig. 11. *Sarcodon fumosus*. No. 8193.
Figs. 12–16. *Hygrophorus minutulus*. No. 8197. Figs. 12, 13 show normal basidia. The others may not be true basidia.
Figs. 1–4, 6–10 × 810; figs. 5, 12–15 × 503; figs. 11, 16 × 1620

PLATE 22

Figs. 1 and 2. *Cyphella tsugae*. Haywood County, N. C. Entire plants.
Fig. 3. *Cyphella tsugae*. Hymenium.
Fig. 4. *Craterellus albomarginatus*. No. 8206.
Fig. 5. *Amanita Gwyniana*. No. 8149.
Fig. 6. *Amanita Roanokensis*. No. 8255.
Fig. 7. *Marasmius nigripes*. No. 8154.
Fig. 8. *Sarcodon Murrillii*. No. 8028.
Fig. 9. *Polyporus holocyaneus*. No. 8202.
Fig. 10. *Ganoderma ohiensis*. Haywood County, N. C.
Fig. 11. *Ganoderma ohiensis*. Mountain Lake, Va. (Murrill, No. 393).
Figs. 1, 2 × 20; fig. 3 × 647; others × 1620

LARS ROMELL

Lars Romell, noted mycologist of Stockholm, Sweden, died suddenly of heart failure on the night of July 12, 1927. His son, Dr. L. R. Romell of Djursholm, Sweden, has kindly furnished me with certain biographical data concerning his father and also a list of his publications. As this data will certainly be welcome to Dr. Romell's many friends in this country, I will give it in modified form below.

He was born on December 4, 1854, at Kumla in the province of Marke, Sweden. He finished at the Orebro läroverk (high school) on May 29, 1876, and took his bachelor of arts degree at the University of Upsala in May 1885. Shortly before his death he was voted the degree of Doctor *Honoris Causa* by the University of Upsala. As this honor was to be bestowed on him in September, he died without receiving it, but the faculty brought the laurel wreath to his funeral. Before graduating in 1885 he was assistant master at the seminary or training school for teachers at Falun (1878–1882). After graduating from Upsala, in order to further prepare himself for teaching, he spent one year (1886) at the College of Högre Reallläroverket (science school), Stockholm. He then taught for a year at the College of Norra Latinläroverk, Stockholm. For the following three years (1887–1890) he was adjunct master at Ostermalms Läroverk, Stockholm.

In 1890 he gave up teaching and went into the practice of patent law, by which profession he lived until his death. As a patent attorney Dr. Romell was held in the highest admiration by men of his profession and by patent officials. He was notable for his scrupulous and intelligent work and for a most extraordinary energy. At his funeral he was signally honored by the personnel of the patent office as well as by numerous botanical institutions and foundations. During five of his later years (about 1915–1920), Dr. Romell was engaged for part of his time in organizing and systematizing the fungal collections in the Riks Museum of Natural History near Stockholm.

As a botanist Romell's fame rests on his contributions in the field of mycology. His interest in fungi was first aroused by Hampus von Post of Upsala, with whom he kept up a very close friendship until the death of the latter in 1911. As von Post had been associated with

LARS ROMELL
(1854-1927)

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Elias Fries in the study of fungi, Romell had the great advantage of having an intimate personal connection with the knowledge and traditions of this great man. Romell has for years been recognized as the greatest living authority on the Friesian species of higher fungi. Just before his death he was planning an edition of some of the unpublished colored plates of Fries, with critical notes of his own.

Romell left large collections of fungi, many thousand photographs of fungi and their spores, several thousand prepared slides of spores, voluminous paintings and written notes. In 1920 he added to his already large herbarium the very fine and valuable herbarium of Abbé Bresadola of the Trentino, for which he paid about 18,000 Swedish crowns, an outlay which made necessary the most severe economies on his part. His extensive correspondence with mycologists all over the world is preserved intact, both the originals and copies of his replies.

In addition to the above facts, Dr. L. R. Romell furnishes me with some interesting personal interpretations of his father's character and habits. With slight changes in wording and phraseology, I give in the next three paragraphs the main part of this estimate.

Dr. Romell was a very original man who sacrificed everything that ordinary mortals hold dear for the sake of his ideals and interests, among which spiritualism, occultism, and such things took perhaps as large a place as did mycology. He worked every minute when he was not sleeping or eating, and he made it a duty to eat as simply and cheaply as possible, even refusing to sit down while eating in order to save time. When hungry he went to the kitchen to get in a hurry some carbohydrates, fats and proteins from the cupboard. This was, however, not so much asceticism as it would seem, for if he had ever had a normal interest in a good meal he had lost it long ago. A better proof of his ascetic tendencies was that although he was very fond of perfumes the only thing of this kind that he allowed himself, except *Anthoxanthum odoratum*, which did not cost anything, was the cheap and offensive nitrobenzol. He ate practically no fungi except those which were regarded as poisonous, and these he ate in order to test the truth of this opinion. He gave up this practice, however, some years ago after being made very ill by eating *Entoloma lividum*. His solid constitution supported all this unhealthy life marvellously: the only serious injury he had from it was once before the era of vitamines when he had a case of scorbutus, though living in a well furnished town.

He was a typical enthusiast, always more or less obsessed by his ideas, and, in spite of his great modesty, with a certain tendency to do mission-

ary work. His first plan on leaving home to study was to be a preacher or missionary. Having lost in Upsala his Christian faith, he became an ardent free-thinker, and his withdrawal from the teaching profession in 1890 was caused by a conflict he had with the parents of his scholars and the rector of the school because of his propagating anti-Christian opinions in his classes. During the great war he bought and distributed masses of pamphlets of the well known type in order to combat the "wrong" ideas prevailing in Sweden as to the "right" in the war, and he was absolutely blind to the underlying aims and purposes of the pamphlets. He tried also to stop the war by writing to the Queen of Germany and to the Pope! He had, alas, too great a belief in the power of reason, truth and right in the world.

Dr. Romell had a rich, all-round intelligence, though his obsessions hindered the complete unfolding of his spiritual personality. He never read a novel or light literature because he liked only "truth," not "invention." Although very interested in music in his youth, he abandoned this altogether in later years. He had a fine sense for colors, of which his water-color paintings of fungi bear witness, but he never saw the bluish tint on distant mountains because he *knew* that in truth, when viewed from near at hand, they were gray. The ease with which he seized a new thought or invention, for example in technical things, his good style, and his facility for learning written languages were of great practical use to him in his work as patent attorney.

In 1920 I (W. C. C.) visited Stockholm for the purpose of studying fungi in Fries' own district, and at once looked up Dr. Romell, with whom I had previously corresponded. He immediately placed everything he had at my disposal and with unparalleled generosity both in time and materials gave me assistance for the entire month I was in Stockholm. He had housed the Bresadola collection in the Riks Museum at the time, and allowed me full use of its material. Available there also, of course, were other large collections of fungi, notably material from the Sydows.

The impression one got of Dr. Romell was that he scarcely took time to eat and sleep. He worked with intense earnestness and his interest in mycology seemed to increase rather than diminish with his years. He took frequent excursions with the same enthusiasm as ever in his last days. His son writes me that two days before his death he made one of these excursions to collect fungi, and on the day before his death he made mycological notes in his books. The amount of trouble that

Dr. Romell would take to satisfy any request made of him by mycological friends was almost unbelievable. A month before he died I wrote asking him for plants that he considered representative of Fries' interpretation of *Amanita solitaria* and *A. strobiliformis*. He replied that Fries had seen only one specimen of *solitaria*, sent him from Fogelsta (?) by a landowner named Tamm. He said further that the nearest railway station to Fogelsta was 135 kilometers from Stockholm and that from there one could take a bus or auto to the farm where the plant was found. Instead of dismissing the matter in this way, he added that he would try to find it for me there this year!

I had a warm affection for the man. To a mind of unusual power and accuracy, he added an elevation of character and beauty of spirit that deeply impressed all who knew him. We are glad to be able to publish a photograph of him taken on his seventieth birthday.

W. C. COKER.

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Abbreviations used

Bot. Not. = Botaniska notiser (Lund, Sweden).

Kungl. Vet.-Akad. Övers. = Översikt av Kungliga Vetenskapsakademiens förhandlingar (Stockholm)

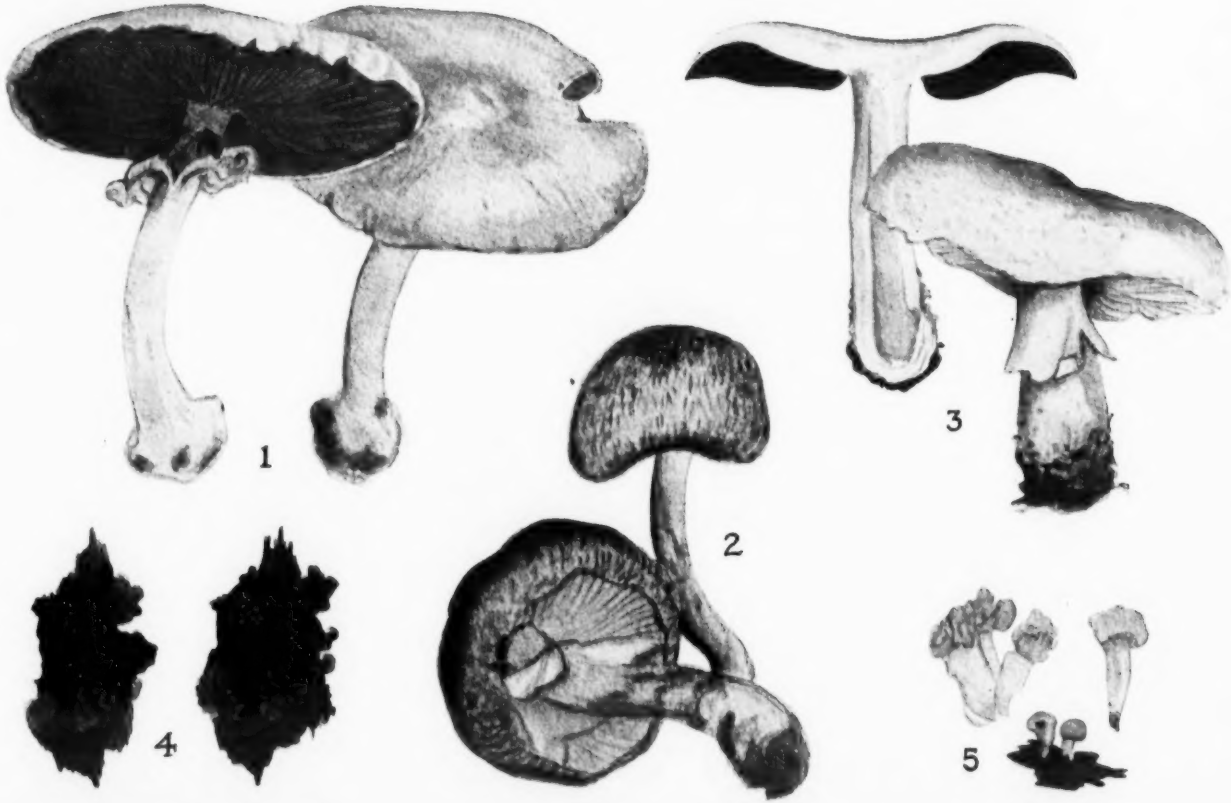
Bih. K. V. A. Handl. = Bihang till Kungliga Vetenskapsakademiens Handlingar (Stockholm).

Arkiv för botanik is edited by the same Academy.

Sv. bot. tidskr. = Svensk botanisk tidskrift (Stockholm), edited by the Svenska botaniska föreningen.

Z. f. Pilzk = Zeitschrift für Pilzkunde (at first published at Heilbronn a/N, now Leipzig), which supplanted the Pilz- und Kräuterfreund (Heilbronn), edited by the Deutsche Gesellschaft für Pilzkunde.

Schweiz. Z. f. Pilzk. = Schweizerische Zeitschrift für Pilzkunde (Burgdorf, Switzerland).



Painted by Dorothy Coker and Cornelia S. Love.

Fig. 1. Psalliota abruptibulba. No. 1262. Fig. 2. Psalliota auricolor. No. 3274. Fig. 3. Psalliota silvatica. No. 1265. Fig. 4. Sirobasidium sanguineum. No. 4728. Fig. 5. Dacryomitra glossoides. No. 4417. All natural size except two upper in fig. 5 which are × 2.

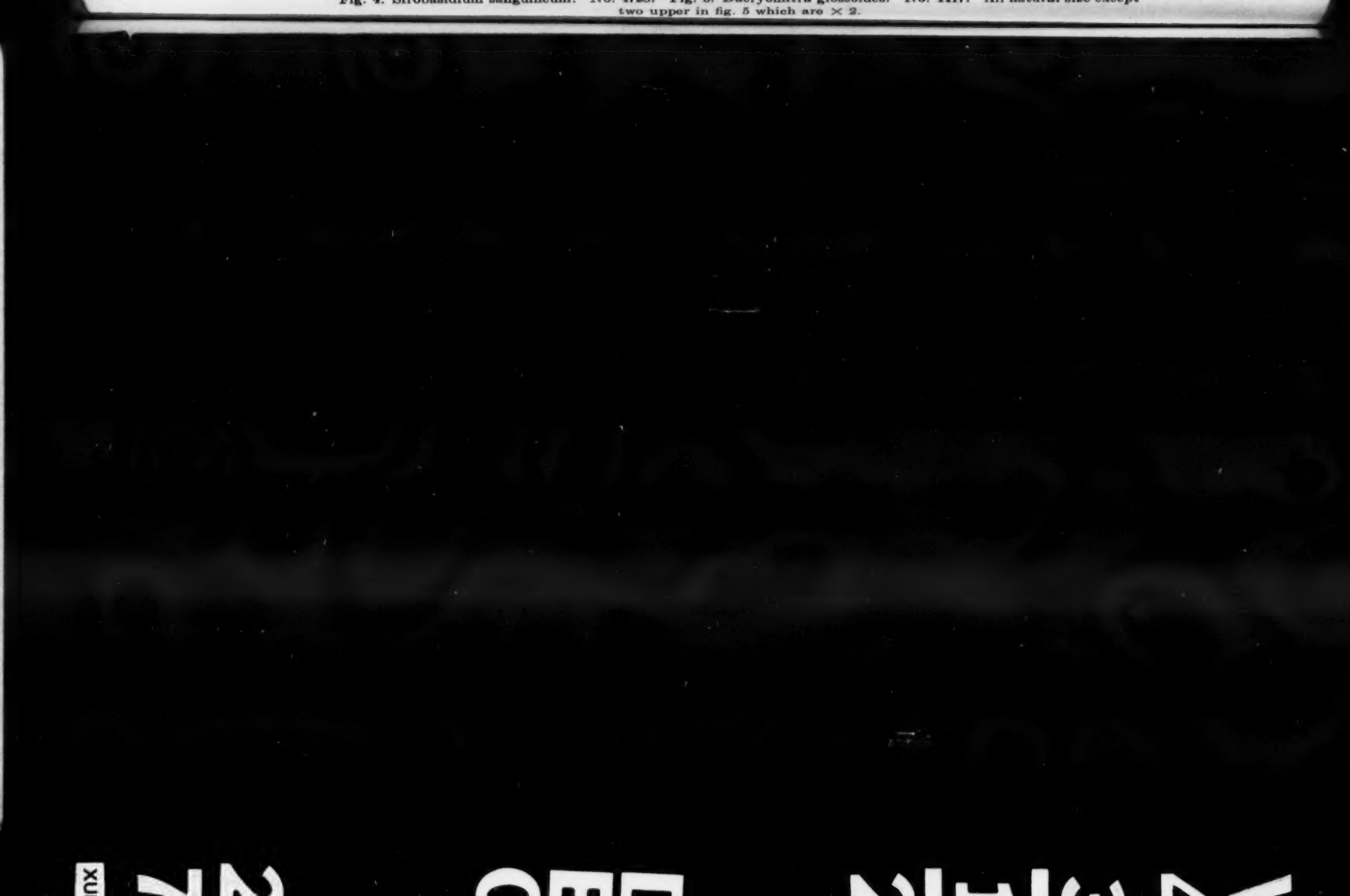


Fig. 4. Strobilidium sanguineum. No. 4725. Fig. 5. Dactylochlora glaucoides. No. 4727. All natural size except two upper in fig. 5 which are × 2.